Département territoires, environnement et acteurs
Cirad-tera

Rapport de Mission Indonésie

Participation à l'atelier de travail FLORES (Forest Land Oriented Resource Envisioning System) et formation Systèmes Multi-Agents au Cifor

Martine Antona
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Août 1999
TERA N° 62/99
Programme Espaces Ressources

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Mots clés : Dynamiques forestières, modélisation, systèmes multi-agents, formation.

Résumé

Cette mission avait deux objectifs :

- le premier objectif était de participer à un atelier de travail sur la création de modèle pour la dynamique forestière. A l'initiative du Cifor, cinquante personnes ont été réunies pendant deux semaines pour concevoir un modèle. La méthode utilisée est la dynamique des systèmes ;

- le deuxième objectif était de proposer une formation aux systèmes multi-agents auprès de partenaires invités par le Cifor et le Cirad.

La mission en Indonésie avait pour but de participer à un atelier de travail puis de conduire un cours de formation aux systèmes multi-agents au CIFOR et, enfin, de participer avec Philippe GUIZOL à la rédaction d'un thème du programme Plantation du CIRAD-FORET. Ces deux dernières activités faisaient partie d'une opération plus générale d'appui au projet de Philippe GUIZOL sur la viabilité à long terme des systèmes de plantations au sein du CIFOR.

Chronologie

21/01/99	Arrivée à Jambi (Sumatra)
22/01/99	Séance plénière de présentation du workshop, jeu Fishbanks organisé par les Ciradiens.
23/01/99	Voyage entre Jambi et Muara Bongo
24/01/99	Visites de terrain et arrivée à Buttikingi
25/01/99	Début du travail sur la modélisation en séance plénière.
26-29/01/99	Travail en sous groupes. Martine ANTONA et François BOUSQUET faisaient partie d'un groupe de huit personnes censées proposer un modèle de processus de prise de décision. Un compte-rendu des activités de ces quatre jours figure en annexe.
01-04/02/99	Assemblage des sous-modèles (décision, crop-soil, Non Timber Forest Product, Corporate, trees and forest).
04/02/99	Retour à Bogor.
05-08/02/99	Cours au CIFOR, dont un séminaire d'une heure pour les chercheurs du CIFOR et de l'ICRAF.
09/02/99	Travail avec P. GUIZOL et départ.

FLORES : modélisation du processus de décision

Du 22 janvier au 04 février 1999, le CIFOR, organisateur principal, le CIRAD, l'Université d'Edimbourgh et l'ICRAF ont organisé un workshop appelé Flores (Forest Land Oriented Resource Envioning System Model Design Workshop). Le but de cet atelier de travail était de construire un modèle pour simuler la dynamique du paysage dans les zones forestières. Flores est censé aider à l'exploration à l'échelle du paysan des conséquences de décisions prises par des responsables politiques ou d'autres acteurs qui veulent influencer l'aménagement du territoire.

Les formes de cet atelier sont issues des ateliers de travail proposés par C.S. HOLLING comme, par exemple, le modèle Serengeti qui avait servi à évaluer les alternatives de gestion de l'écosystème Seregenti (voir annexe 1). Le processus qui a présidé lors de l'atelier Flores et lors de sa préparation corresponde à la méthode présentée par HOLLING sous le nom de Adaptative Environmental Assessment and Management.

La préparation et la tenue de l'atelier ont été conduites par Jerry VANCLAY, chercheur du CIFOR. Deux réunions à Montpellier, en mai et septembre 1998, ont initié le processus. Au cours de l'automne 1998, un forum électronique de discussion a préparé le workshop, un site web a été créé avec les textes introductifs.

Cinquante personnes ont participé au travail. Trois personnes du CIRAD ont participé, sous financement du CIRAD-FORET : M. ANTONA, P. GUIZOL et F. BOUSQUET.

1. Organisation

1.1. Objet de la modélisation et visite de terrain

Après les journées de présentations et les visites de terrain, des sous-groupes se sont formés pour modéliser différentes parties du processus de dynamique du paysage et de ses usages. Les sous-groupes correspondaient à une équipe sur les sols et les cultures, une sur les arbres et les forêts, une sur la biodiversité et les produits de la forêt autres que le bois, une sur les décisions externes aux systèmes (administrateurs, ONGs, etc...).

1.2. Séances plénières

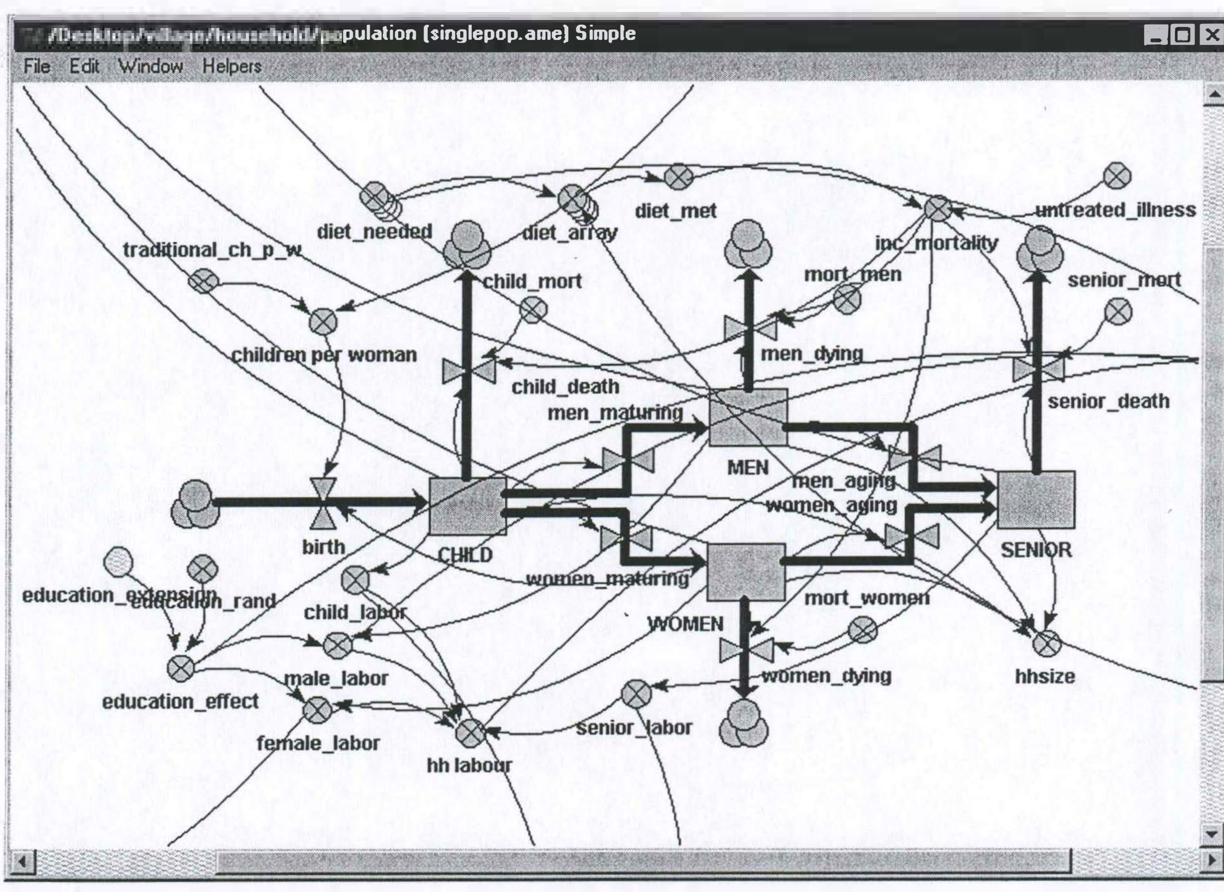
Tous les matins se déroulaient des séances plénières. Au cours des premières séances plénières, il fut décidé de travailler à l'échelle spatiale de trois villages (25 km^2) avec 30 ménages par village. La cellule spatiale de base avait une surface de un hectare. Il fut décidé de ne pas prendre en compte les phénomènes de migration, de considérer qu'un seul ménage peut exploiter un champ (une cellule).

1.3. Travaux de groupes

Le sous-groupe dans lequel nous étions devait se consacrer à la modélisation du processus de prise de décision au niveau des ménages. Le pari était de produire un modèle de quatre jours. Pour cela, il fallait représenter le processus observé dans les villages visités dans la région de Sumatra et décrits par les chercheurs de terrain. Le groupe était composé de 8 personnes aux origines diverses : des spécialistes de la région Sumatra, Carole Colfer anthropologue, Laxmann Joshi écologue, ou plus

largement des systèmes agraires David Thomas, un anthropologue spécialiste des systèmes de gestion des ressources Chimère Ndiaw, une économiste Martine Antona et trois modélisateurs, un géographe Tom Evans et deux spécialistes de l'Intelligence Artificielle Mandy Hagith et François Bousquet. F. Bousquet était facilitateur de ce groupe. La première journée de travail en groupe fut consacrée à la compréhension des processus de décision locaux à partir de discussions et de textes produits par Carol Colfer. Au cours de l'après-midi du premier jour, le travail a consisté à une première élicitation des connaissances. Il s'agissait de transcrire les connaissances en terme d'objets, de variables et d'influences. Il fut alors convenu que le groupe s'attacherait en premier lieu à représenter les décisions d'activité des ménages au cours d'une année de culture.
A partir de ce premier travail, trois sous-modèles ont été identifiés. Le premier correspondait à un modèle de démographie pour prendre en compte la dynamique de la composition du ménage qui influe sur la quantité de travail disponible, sur leur consommation et sur leurs besoins d'éducation. Le second sous-modèle correspondait à un modèle de composition et d'affectation des revenus. Le troisième sous-modèle correspondait à un module de décision des ménages sur la répartition de leur force de travail suivant les différentes activités situées dans l'espace. Après une discussion sur l'architecture générale du modèle de ménage et donc sur les liens entre les trois sous-modèles, le groupe s'est répartit en trois sous-groupes : M. Antona s'est consacrée à la création du sous-modèle sur les revenus avec D. Thomas, M. Haggith, tandis que C. Colfer et F. Bousquet proposaient une représentation des décisions d'activité.

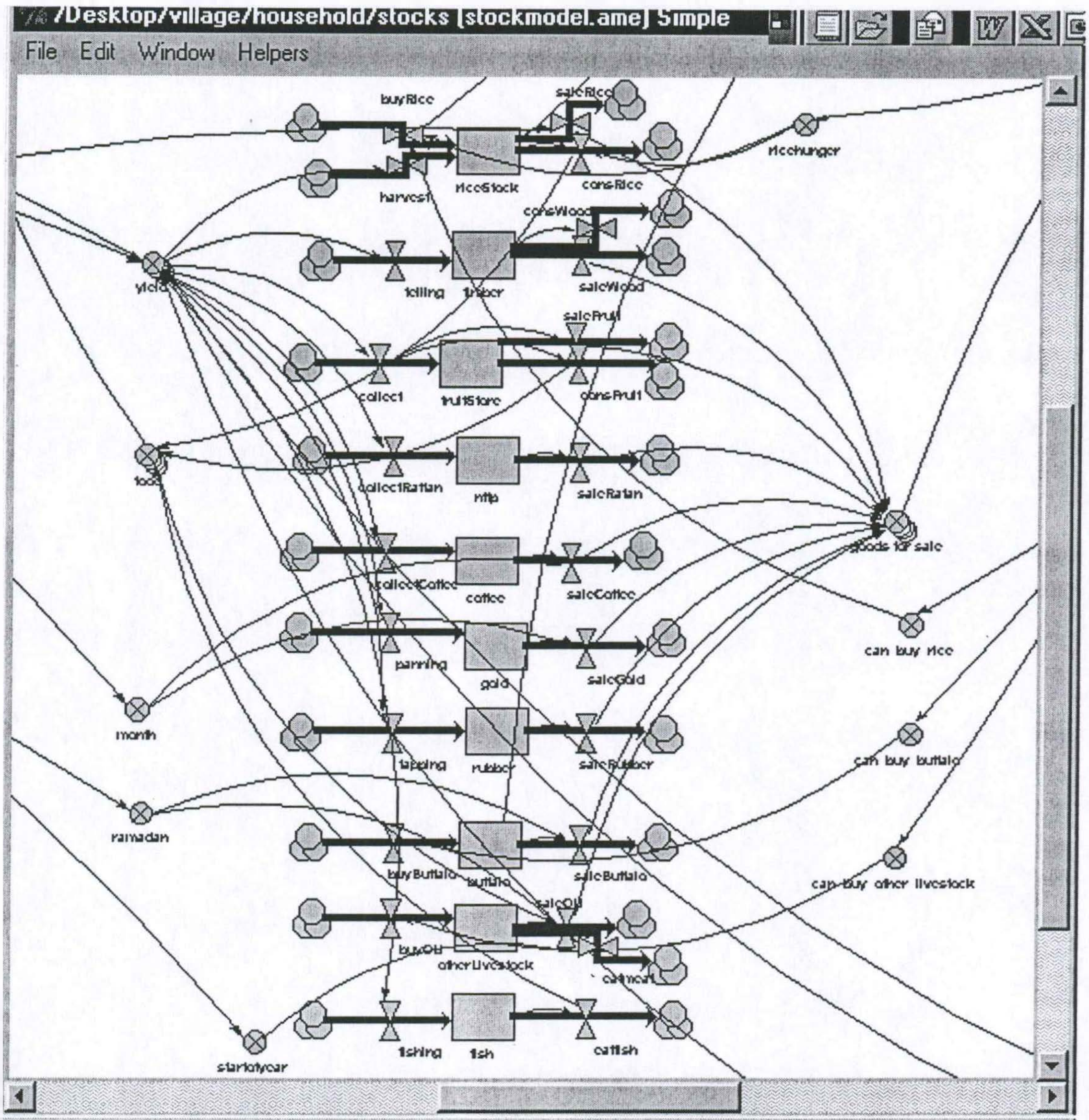
Le modèle démographie :



le sous-modèle est élaboré pour fournir le montant et le type de travail disponible au sein de chaque ménage (homme, femme, enfants, seniors en fonction de taux de mortalité et de fécondité fixés. Hommes et femmes adultes sont différenciés par leur force de travail : un taux de conversion a été choisi.

Le nombre de ménages est fixe ; les phénomènes de migration et de segmentation ne sont pas pris en compte. La dynamique est simulée par l'augmentation du nombre de personnes du ménage, qui est l'unité de décision...
Le nombre d'adultes et enfants en activité est calculé en soustrayant aux membres du ménage, un nombre de personnes suivant un cycle d'éducation (le taux d'éducation constitue un "policy lever"). Ce résultat est transmis aux autres sous-modèles incluant la composante allocation du travail.

Sous-modèle économie

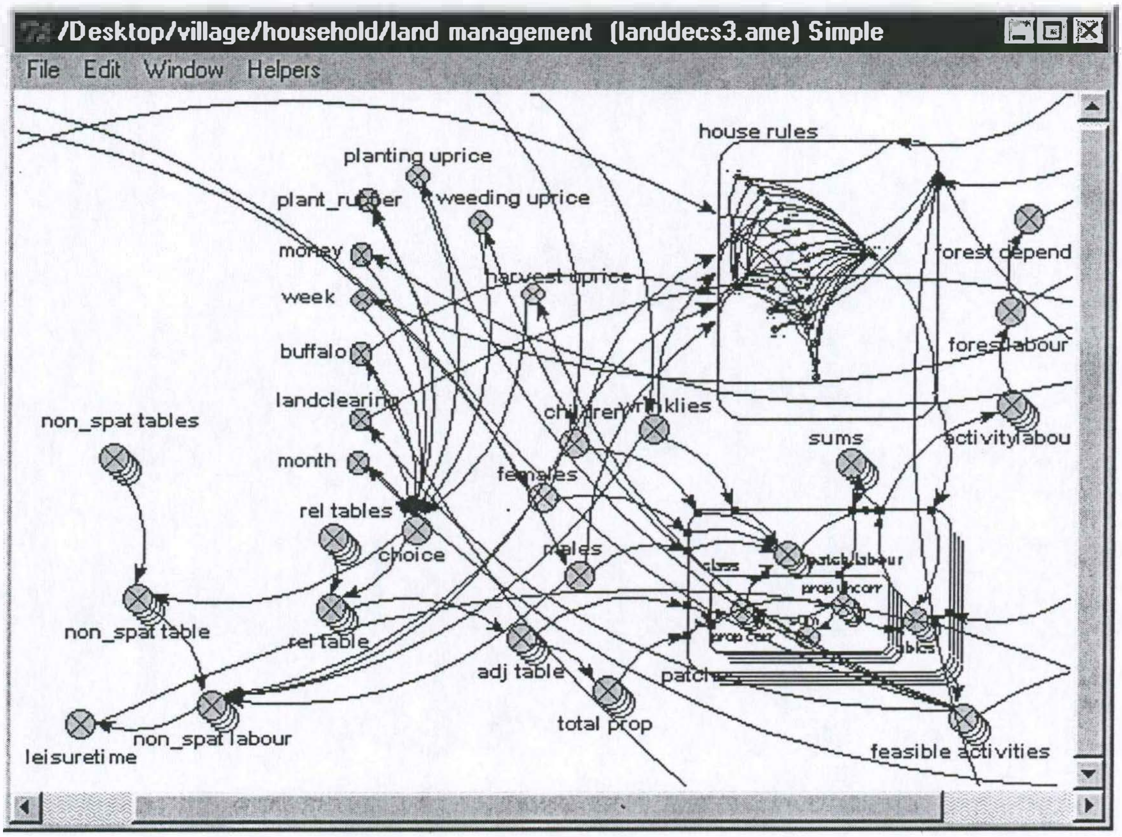


Un des éléments qui a conduit la modélisation du ménage fut la demande du groupe des Clients qui désiraient des indicateurs. Ces indicateurs sont produits à l'échelle du ménage et ensuite agrégés au niveau du Village.

- Pour une simulation au pas de temps hebdomadaire les coûts de production et la consommation sont pris en compte durant la même semaine alors que les revenus de la production et des activités non agricoles sont pris en compte la semaine suivante . Cela conduit à un modèle à deux périodes. Le premier sous-modèle prend en compte les quantités produites vendues et consommées. Le second sous-modèle utilise les sorties du premier pour calculer les revenus (pour la consommation de nourriture, autres dépenses, coûts des intrants) ainsi que la dette ou l'investissement. Les prix, les salaires sont considérés comme exogènes, C.A.D fixés.

- La consommation est un ensemble de niveaux de subsistance, non dépendante des prix relatifs. Cela veut dire que la consommation n'augmentera pas avec une plus grande quantité de produits de l'agriculture. L'excès résultant sera alloué à la réduction de la dette ou de l'investissement. Dans ce cadre, nous considérons que l'éducation et la santé ne dépendent pas des résultats de l'activité agricole mais du modèle de population. Ainsi des ménages en déficit de revenu seront endettés. L'impossibilité de payer les coûts de soin résulte en une plus grande mortalité.
- Les coûts de production sont dépendants des revenus. Ces coûts sont déduits des revenus après avoir pris en compte les dépenses alimentaires, les dépenses d'éducation et de santé. Lorsque les revenus ne sont pas suffisants pour couvrir les coûts de production du ménage l'activité du ménage devient impossible pour ce pas de temps. Lorsqu'au contraire un surplus existe il est investit en buffles ou autres types d'élevages.

Sous modèle décision



Deux approches étaient possibles. La première étaient que les ménages allouent leur quantité de travail en fonction des demandes de leur environnement de production. Cela sous entend un ménage rationnel qui calcule et optimise sa quantité de ressources dont le travail. L'autre approche est de considérer des ménages qui allouent leur travail en fonction de la saison, en fonction de la disponibilité de travail et en fonction des priorités. Cela implique un ménage adapté à son environnement et qui a acquis des connaissances sur ses activités. Puisque le site sélectionné pour le travail de Flores a un faible niveau d'intégration au marché, le groupe que nous formions a choisi la deuxième approche.
Nous avons tout d'abord travaillé sur les perceptions du ménage et les conditions qui influent sur son activité. Il y a des conditions qui répondent à l'état de ses champs et des conditions sur l'état du ménage lui même. En combinant ces deux conditions, nous calculons un vecteur de faisabilité pour chacune des activités. En ce qui concerne par exemple les travaux de préparation à la culture de riz en forêt (upland) il y a des conditions sur l'état de la parcelle (il faut par exemple que la production soit inférieure à 100kg d'hévéa/ha/an) et il y a des conditions sur l'état du ménage (il faut que deux

personnes puissent travailler, que le ménage dispose de plus de 300 KRp, le coût de l'équipement tel une tronçonneuse ou un buffle.
Il existe un ensemble d'activités spécialisées, de loisir, d'éducation des enfants qui ne requière pas l'activation du sous modèle décision. Il existe aussi des activités non spécialisées pour lesquelles des règles ont été écrites. Ces règles font référence à des conditions sur les parcelles, par exemple l'état de la forêt pour les activités d'exploitation du bois. Des variables ont été créées sur les objets parcelle. Pour chaque activité possible, ces variables sont des booléens qui prennent la valeur 0 ou 1. L'activité dépend aussi de l'état du ménage et en conséquence les mêmes variables ont été créées sur les objets Ménage. Ces deux vecteurs de booléens sont combinés pour définir quelles activités sont possibles et sur quelles parcelles. Nous avons ensuite travaillé sur l'allocation du temps sur ces actions. Cette allocation du temps pour les différentes classes (hommes, femmes, enfants et seniors) dépendent des conditions sur par exemple la quantité d'argent disponible.
A partir de ces conditions, nous avons défini des distributions d'activité qui furent ensuite allouées aux différentes parcelles. Cette distribution est définie par la proportion d'activité allouée aux différentes taches (par ex. ouvrir des parcelles, entretien des champs) par différentes catégories de personnes (hommes, femmes) multiplié par le nombre de personnes du ménage dans chacune de ces catégories. Dix neuf tables d'allocation du temps ont été écrites comme des variables appelées « rel table ». La priorité est donnée au travail productif (riz, hévéa, travail hors exploitation, et collecte de produits de la forêt dans l'ordre décroissant d'importance). Cette allocation du travail est combinée avec les possibilités « ables » pour donner un vecteur « patch labor ». Ce résultat, qui est un tableau (activité, parcelle, quantité de travail) est le principal output du modèle de décision, pour l'interaction avec la dynamique naturelle

Les trois sous modèles ont ensuite été reliés. Cette opération fut assez aisée car le lien principal concerne :

1. la quantité de travail disponible chez les hommes, les femmes, les enfants et personnes âgées qui sera convertie en activité sur les parcelles,
2. la quantité d'argent dont dispose le ménage car certaines activités nécessitent un apport financier.

Après avoir relié ces trois sous modèles le modèle global de ménage fut relié au reste du modèle. Pour cela trois types de liens furent nécessaire.

- Le lien entre le modèle de ménage et la parcelle se fait dans deux directions. Tout d'abord le ménage a besoin de recevoir des informations de la parcelle pour envisager ses activités. Il y a donc un marqueur sur chacune des parcelles pour savoir si une activité est possible du point de vue des caractéristiques de la parcelle. Dans l'autre sens la parcelle renvoie des résultats d'activité des ménages, en remplissant les stocks correspondant. Ainsi pour une activité de récolte de riz, le stock de riz du ménage se trouvera augmenté.
- Le lien entre le ménage et le groupe Clients. Ce dernier groupe a besoin de beaucoup de données agrégées sur les différents ménages.

Au moment ou le worskhop s'est terminé les différents modules étaient assemblés. Il restait donc à effectuer la phase de vérification, puis la phase de calibration. Un contrat fut proposé à Mandy Haggith pour mener à bien cette opération en relation avec Jasper Taylor.
Le dernier jour les discussions ont porté sur l'usage de ce modèle ; les points de vue étaient très variés. Pour certains beaucoup reste à faire et le modèle en tant que tel est inutilisable, mais il a une vertu de « group building » et permet de tracer des directions de recherche. Pour d'autres le modèle doit pouvoir être utilisé dans des délais assez courts et doit pouvoir être transposé à d'autres terrains. En promenant le modèle de terrains en terrains on l'améliorera. Devant la diversité des approches il fut convenu de donner une peu de temps au processus et de voir quelles personnes et quelles institutions allaient s'approprier la dynamique. Deux groupes sont importants, Jerry Vanclay l'organisateur principal qui part s'installer en Australie et quitte donc le Cifor, et le groupe Ecossais avec les modélisateurs d'Edimburgh qui développent le logiciel AME. Au moment ou nous partions nous apprenions que le principal bailleur britannique relançait financièrement le projet. Du 19 au 21 Mai les modélisateurs écossais ont prévu un séjour à Montpellier pour poursuivre le modèle de décision.

L'orientation du nouveau travail se porte essentiellement vers la représentation de l'allocation des terres.

2 Leçons de l'expérience

Cette expérience fut très riche et on peut en tirer des leçons de différents ordres. Tout d'abord on peut discuter de l'état du modèle élaboré ce qui renvoie au statut de ce type de modélisation. Enfin on pourra mettre en avant quelques enseignements sur l'organisation de ce type d'événement.

2.1 Etat du modèle.

Tel qu'il est présenté le modèle est très compliqué. Pourtant de nombreux processus n'ont pas été pris en compte. Nous en recensons ici quelques uns, les autre figurent en annexe:

Les éléments du système

- Un seul groupe ethnique a été pris en compte (pas de transmigrants)
- Les plantations industrielles et les projets d'hévéa ne sont pas pris en compte
- Les jardins de case n'ont pas été pris en compte en raison de l'échelle spatiale choisie (ils font moins de un hectare de surface)

Le temps

- Les décisions stratégiques qui prennent en compte le long terme (envoyer les enfants à l'école, achetre un véhicule ...) n'ont pas été modélisées. Le ménage n'a pas de mémoire et ne changera donc pas d'utilisation de l'espace au cours du temps.

Au niveau du ménage

- Réduction au niveau du village implique d'abandonner le niveau village, clan et individu.
- Les droits coutumiers et les règles foncières ont été très simplifiées en raison de ce niveau choisi et de la difficulté à faire de multiples liens entre objets avec AME.
- La quantité de ménages est fixe et la démographie s'exprime à l'intérieur du ménage.

De nombreux autres points sont répertoriés en annexe. Une remarque importante à la fin du processus : le défi du modèle Flores est de représenter le maximum d'éléments, d'être le plus proche de la réalité possible, pourtant à la fin du processus criants sont les manques du modèle. Cela nous confirme dans l'idée que l'objectif de représenter un modèle "aussi complexe que la réalité" est d'une part discutable pour son usage mais peut aussi s'avérer contre productif en s'exposant à la critique des inévitables manques du modèle.

2.2 A propos d'AME

L'originalité d'AME par rapport à d'autres produits dans le commerce est de coupler la notion de représentation systémique, (en boîtes qui représentent des stocks, flèches qui représentent des flux et des relations d'influence et variables) à la notion d'objet. Ce double formalisme offre potentiellement une grande richesse de représentation. Dans la pratique, on peut tirer des leçons différentes suivant les groupes de travail. Pour les groupes qui se sont attachés à représenter les dynamiques naturelles (groupes sol, croissance des arbres, biodiversité) la modélisation est naturellement représentée en

termes de stocks et de flux). La modélisation systémique est naturelle et son histoire est longue dans ces disciplines. L'apport de l'objet consiste essentiellement à pouvoir créer de multiples instances. Ainsi le modèle dynamique d'une parcelle peut être reproduit pour autant d'instances. Cela rejoint la notion de tableau de parcelles tel que le géreraient des logiciels plus classiques comme Stella, avec cependant beaucoup plus de souplesse. Pour le modèle de décision, nous attendions beaucoup de la représentation objet. En effet, si la modélisation systémique se prête bien à la représentation de stocks de produits ou de relations entre des variables économiques la représentation objet devait nous donner accès à d'autres dimensions. Outre la notion de classe et d'instance dont on a vu l'usage pour les dynamiques naturelles et que l'on retrouve à travers la possibilité de créer de multiples instances de la classe Ménage, la représentation objet doit apporter la possibilité de modéliser des interactions entre les objets qui passe par la notion de message. Or cette notion n'existe pas dans Ame. Pour représenter des interactions entre instances de Ménage il faut créer une variable extérieure qui est un tableau de tous les ménages. Chaque ménage a accès à ce tableau et pourra interagir avec les autres ménages par un accès indexé. En pratique cela s'avère malaisé et nous n'avons pas utilisé ces potentialités qu'offre l'objet.
Ame est un produit universitaire en constante évolution qui cherche à intégrer de nouveaux concepts. Il est d'usage intéressant pour ceux qui ont un mode de représentation essentiellement systémique et qui veulent s'associer avec le groupe de recherche Ecossais.

3 Conclusion

Le processus Flores est maintenant initié. Quel sera son devenir? Celui qui est à l'origine du processus, Jerry Vanclay, a quitté le Cifor juste après la rencontre pour s'installer en Australie. Le Cifor ne paraît pas très engagé dans ce processus et n'a pas donné depuis de signes d'appropriation pour conserver le leadership du processus. Le Dfid, le bailleur de fonds britanique a redonné des fonds substantiels pour que le modèle soit amélioré d'ici la fin de l'année 99. La plus grande partie de ces fonds a pri la direction d'Edimburgh. L'objectif est d'améliorer essentiellement le modèle du processus de décision. Pour cela un contrat à durée déterminée a été proposé à Mandi Haggith. Comment ce modèle sera-t-il amélioré? Nous n'avons que peu d'éléments. Il semble que d'une part, les aspects fonciers devront être améliorés mais d'autre part nous n'avons que peu de contrôle sur le devenir du modèle de décision. Ainsi une réflexion a débuté sur ce thème. Le Cirad, à Montpellier, a pris le rôle d'acteur à consulter. Le but de l'opération est de pouvoir montrer ce modèle à la fin de l'année à d'éventuels bailleurs de fonds pour continuer. Les autres instituts ne donnent que peu de signes de vie.
Il nous paraît aujourd'hui important que le Cirad, à travers les départements Forêt et Tera, prenne une position.

Formation sur les Systèmes multi –agents

Les 5, 6 et 8 février, un cours a été organisé au CIFOR pour introduire aux concepts des systèmes multi-agents et pour initier à l'usage de l'outil Cormas. Dix sept personnes étaient invitées sous financement du programme plantations du CIFOR dirigé par C. Cossalter.

La formation se composait de cours le matin et de travaux pratiques l'après-midi. Les personnes présentes (dont la liste est en annexe) étaient d'origine disciplinaire diverse, informaticiens, économistes, forestiers. La plupart venaient d'Indonésie mais Philippe Guizol avait aussi invité des Malaisiens et des personnes travaillant sur de terrains au Vietnam. Lors de la dernière après midi nous avons présenté le modèle d'irrigation sous forme d'un jeu de rôle. Le travail que nous avons mené ces trois jours dans les locaux du Cifor a en partie convaincu des chercheurs du Cifor appartenant au programme co-adapttive management (Carol Colfer et Ravi Prabhu). Une des conséquences fut l'accueil d'Herri Purnomo, informaticien de leur programme à Montpellier pensant un mois pour se former à Cormas, avec un financement de l'Ambassade à Djakarta.. Cette formation introduit un informaticien formé dans les locaux du Cifor ce qui devrait favoriser les travaux de Philippe Guizol pour le volet modélisation.

Serengeti II

Dynamics, Management, and Conservation of an Ecosystem

Edited by
A. R. E. Sinclair & Peter Arcese

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TWENTY-NINE

A Model to Evaluate Alternative Management Policies for the Serengeti-Mara Ecosystem

R. Hilborn et al.

The Serengeti has been the site of dozens of research projects since the 1960s, and there have often been as many as fifteen researchers active in the park at any time. This research is well known in both popular and scientific circles around the world, and the contribution of these research programs to our scientific understanding has been great. The list of major books, scientific papers, and films resulting from research in the Serengeti is unrivaled. Yet in the 1990s researchers are under increasing pressure to justify the relevance of their work to the needs of the people living in and around the Serengeti, and to the nation of Tanzania.

The Serengeti ecosystem is affected by many actions of a governmental and nongovernmental nature. Anti-poaching patrols, burning policy, hotel development, animal vaccination in areas surrounding the park, and changing land uses in surrounding areas have become management issues. Further, changes in rainfall pattern, international tourism, and growth of the human population in areas surrounding the park will all have major implications for the plants and animals living in the Serengeti ecosystem. The decision makers in Tanzanian government agencies are actively considering their management options, and it is the responsibility of researchers who work in the Serengeti to ensure that the knowledge they have gained is available to these government officials to help them predict the likely consequences of their management actions.

To assist in this transfer of scientific knowledge from researchers to managers, a workshop was held at the Serengeti Wildlife Research Centre (SWRC) on 7–11 December 1991.* The purposes of the workshop were

*The other participants in the workshop, in random order, are N. Georgiadis, J. Lazarus, J. M. Fryxell, M. D. Broten, B. N. N. Mbano, M. G. Murray, A. R. E. Sinclair, S. M. Durant, B. Mwasaga, M. K. S. Maige, P. Arcese, S. Albon, H. Hofer, M. Kapela, A. Dobson, M. East, H. Nkya, H. T. Dublin, C. Packer, K. L. I. Campbell, S. C. Gascoyne, S. R. Creel, P. Hetz, N. M. Creel, and T. M. Caro.

Indicators of Performance. Once we have chosen the general areas to include, we then list the key indicators of system performance. These indicators are the outputs from the computer model that we will use to evaluate how well any particular management policy performs. The indicators chosen were:

- Animal population sizes
- Tourist numbers
- Tourist satisfaction
- Revenue to national parks
- Employment
- Vegetation condition
- Illegal harvest
- Household income
- Livestock per family
- Encroachment on national parks land
- Local population health care level

Management Actions to Consider. The next step is to decide what management actions we hope to be able to evaluate. These are the analogues of the flight controls on an aircraft flight simulator; those chosen were:

- Poaching enforcement
- Hotel construction
- Livestock vaccination
- Burning and/or suppression of burning
- Road construction
- Adjacent land uses
- Reintroductions
- Improvement of water supply and infrastructure

Spatial and Temporal Resolution. The lists of actions and indicators above can be thought of as the design criteria for our model. They tell us what the model should be able to accept as inputs and what it should produce as outputs. Next we must decide what spatial and temporal scales the model will use. There are a number of options for spatial scale, including (1) a grid pattern, (2) areas of arbitrary size and definition, (3) an explicit model in which each organism has a location in space, and (4) no spatial resolution or implicit spatial resolution.

After some discussion and consideration of computer limitations, we decided on option 2, a model with ten spatial areas as shown in figure 29.1. The areas were chosen to reflect the annual migratory pattern of wildebeest, zebra, and Thomson's gazelle, and to include the areas of significant human impact. Many participants felt that smaller spatial units would be appropriate, but considering that we had only 4 days to build

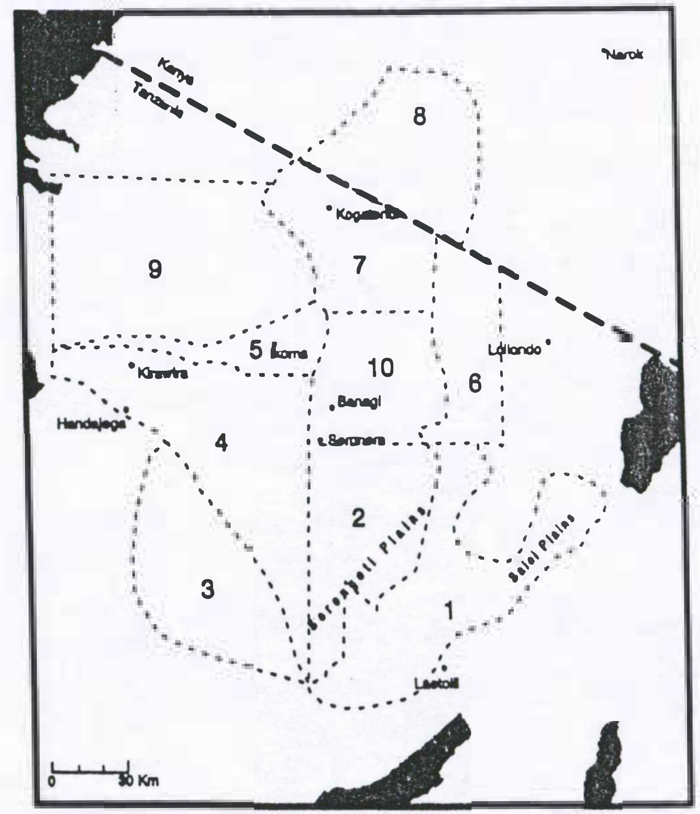

Figure 29.1 Map of the Serengeti ecosystem showing the ten spatial areas of the model: 1, Plains East; 2, Plains; 3, Maswa; 4, Western Corridor; 5, Ikoma; 6, Loliondo; 7, Northern Park; 8, Mara; 9, Northwest; 10, Seronera.

the model and that its purpose was research coordination, we used the areas shown.

The appropriate temporal resolution was also a compromise between conflicting objectives. We elected to consider two seasons, an 8-month wet season and a 4-month dry season. Some parts of the model, such as human population dynamics, did not need to operate on this intra-annual step, but others, particularly vegetation, ungulates, and predators, did need such a division.

Model Components

Subgroups. A key element in the workshop process is to break the participants into groups according to areas of disciplinary specialty, but to use the lists of actions and indicators to ensure that these subgroups spend their time building a submodel that is appropriate to the other groups,

$Woods_{y,i}$ = percentage of area i that is woodland in year y
$Cultiv_{y,i}$ = percentage of area i that is cultivated in year y
$Wild_y$ = total wildebeest population in year y (in thousands)
$pburn_{y,i}$ = the proportion of area i not in cultivation that is burned in year y

The equations for the vegetation model are:

$$Grazed_{y,i} = Wild_y/(1{,}000 + Wild_y)$$

This simply says that the percentage of the area grazed increases as the wildebeest population increases, with 50% of the area grazed when there is a wildebeest population of 1 million. Note that this percentage is determined by the total wildebeest population size because we assume that the distribution of wildebeest is the same in every dry season.

$$Burned_{y,i} = pburn\ (1 - Grazed_{y,i})$$

The variable *pburn* is determined in the parks management submodel, and here we simply assume that areas that have been intensively grazed by wildebeest will not burn.

$$Tallgrass_{y,i} = (7.7 \times Rain_{wet,y} - 202) \times (1 - Burned_{y,i} - Woods_{y,i} - Cultiv_{y,i})$$

$$Green_{y,i} = -800 + Rain_{dry,y} \times 8,$$

or if $Green_{y,i}$ is predicted to be less than 50, then $Green_{y,i} = 50$.

In both of these equations the grass production is assumed to be largely determined by rainfall.

The key interactions of the vegetation with other components of the system are that as the wildebeest population changes, the proportion of the area burned will change, and as land is cultivated or converted to woodland, the amount of grass available will be reduced.

Ungulate Submodel

The following definitions are used in the ungulate submodel:

$N_{y,i,j}$ = numbers of ungulate species j, year y, area i
$Metwt_j$ = metabolic weight of species j
$Resid_{s,i,j}$ = proportion of migratory species j resident in area i in season s
$HalfSat_j$ = the logarithm of dry season grass per animal that produces 50% survival (half saturation)

There are three migratory species in the model—wildebeest, zebra, and Thomson's gazelle—and three nonmigratory species—elephant, buffalo, and "brown animal," which collectively refers to topi, impala, and kongoni. The key relationships in the population dynamics of the ungulates can be summarized as

$$N_{y+1} = N_y\mathrm{SurvDry} + Calves - Hunterkill - Disease\ deaths - Predator\ kills.$$

The number of calves born is simply proportional to the population size:

$$Calves = N_y \times Calving\ rate.$$

The key dynamic factor is the dry season survival, which is assumed to be related to the amount of dry season food per individual by the following relationship:

$$SurvDry = \log(GrassPerAnimal)/[\log(GrassPerAnimal) + HalfSat]$$

where the grass per animal is

$$GrassPerAnimal = (Grass \times area_i \times 100)/(N_{ij} \times Metwt_i \times 1{,}000 \times 120).$$

The numerator is *grass* (kg/ha) times 100 ha per km² times the number of km² in area i. For wildebeest and Thomson's gazelle *grass* is dry season grass. For zebra *grass* is wet season grass/4.5, which reflects the use of long grass during the dry season by zebra but the lower value of the long wet season grass during the dry season. For the nonmigratory species *grass* is the wet season grass divided by 3. The denominator is the number of individuals present, times their metabolic weight, times 1,000 to convert from numbers in thousands to numbers times 120 days in the dry season. The parameters for the starting numbers, metabolic weights, survival, and *HalfSat* values of the ungulates are given in table 29.3.

At the beginning of each season, the migratory species are allocated to the ten areas based on the residence proportions *Resid* shown in table 29.4 and the following equation:

$$N_{y,s,i,j} = N_{y,j}\, Resid_{s,i,j}.$$

Predator Submodel

The predator submodel has two major components: calculation of the kill of prey items, and the population dynamics of the predators. The kill of prey is calculated from the multiprey type II functional response, whose form is

$$Kill_i = \frac{Density_i \times pAttack_i}{1 + \sum_i Handle_i\, Density_i\, pAttack_i}$$

where

$Density_i$ = density of the prey in numbers per ha
$Handle_i$ = handling time for a single predator to consume one prey i
$pAttack_i$ = probability of successful attack on species i
$Kill_i$ = number of prey items of species i killed per unit time

Table 29.7 Population dynamics parameters for predator model.

Species	Lion	Hyena	Cheetah	Leopard	Wild dog
Base mortality	0.02	0.06	0.05	0.02	
Slope of mortality	0.3	0.0	0.076	0.0	
Mortality per poacher trip	1/100,000	1/100,000			
Recruitment maximum parameter	0.052	0.08	0.6	0.0048	0.15
Recruitment slope parameter	−5.31	−0.866	−6	−16	−4.55

Table 29.8 Predator numbers in 1991.

Area	Lion	Hyena	Cheetah	Leopard	Wild dog
1 Plains East	100	2,000	100	0	0
2 Plains	100	1,500	200	0	0
3 Maswa	300	300	35	130	15
4 Western corridor	700	1,800	100	180	20
5 Ikoma	100	700	0	70	10
6 Loliondo	100	200	40	100	12
7 Northern park	300	300	40	110	14
8 Mara	400	1,500	50	130	15
9 Northwest	0	0	0	0	0
10 Seronera	700	1,200	35	120	15

Note: 1960 numbers are assumed to be 60% of 1991 numbers for lion and hyena.

The second component is a large number of calculations of employment and revenues.

The key relationships are as follows:

$$TourismQuality = AnimalQuality \times (1 - Crowding)$$

Tourism quality goes up as more animals are seen, and down as more tourists are present.

$$Crowding = Tourists/(150{,}000 + Tourists)$$

Crowding is an increasing function of the numbers of tourists.

$$AnimalQuality = UngulateQuality + PredatorQuality$$

The more ungulates and predators seen, the better for tourism quality.

$$UngulateQuality = (Wildebeest + Zebra + BrownAnimals)/10$$

Wildebeest, zebra, and brown animals are so much more abundant than other species that they dominate what is seen, but since their numbers are in thousands and we divide by 10, we are saying, in effect, that ten thousand wildebeest are equal to one cheetah.

$$PredatorQuality = 0.5 \times Lions + Cheetahs + Leopards$$

Lions are considered half as valuable as cheetahs and leopards. Hyenas were not considered a tourist attraction.

$$TourismGrowthRate = 1 + Sensitivity \times (TourismQuality - 1{,}800)$$

This is a linear relationship between *TourismQuality* and the growth rate in tourism. When *TourismQuality* is greater than 1,800, tourism will increase; when it is less than 1,800, tourism will decrease. The sensitivity parameter determines how quickly it will increase or decrease, and a value of 4/40,000 was used for base runs. The constants 1,800 and 4/40,000 were selected by trial and error to make the simulations roughly mimic the real system behavior.

The following calculations were made for employment and parks revenue:

$$TotalTourists_{y+1} = TotalTourists_y \times TourismGrowthRate$$
$$TotalTouristNights = TotalTourists \times TouristStayDuration$$

Tourist stay duration is 2 nights.

$$BedsInPark = BedsInPark \times BedGrowthRate$$

The growth rate of beds in the park is specified as a control variable for different scenarios.

$$\begin{aligned} TotalRevenues = {} & (TotalTouristNights \times DailyFee) \\ & + (TotalTouristNightsInHotel \times HotelFeetoParks) \\ & + (TotalCampNights \times CampFee) \end{aligned}$$

The sources of revenue are a daily park fee (\$15.00), a fee from the hotel per night spent in hotel (\$5.00), and a fee per camper night (\$15.00).

Some fraction (50% or 75%) of the total revenue is allocated to the park's operating revenue; the rest is passed on to the Tanzanian government.

The park's residual funds are computed as follows:

$$ResidualFunds = ResidualFunds + OperatingRevenue - OperatingBudget$$

The operating budget has two components:

$$OperatingBudget = AntiPoachingBudget + CapitalImprovements + ParksManagement$$

Employment is assumed to be dependent on the number of tourist nights as follows:

$$ResidentEmployees = 0.6 \times TotalTouristNights/365$$
$$Dependents = ResidentEmployees \times 5$$

Resident employees include both hotel staff and park staff.

Outside Park Submodel

The three major components of the submodel for human activities outside the park were poacher effort and kill, human population growth, and changes in land use outside the park.

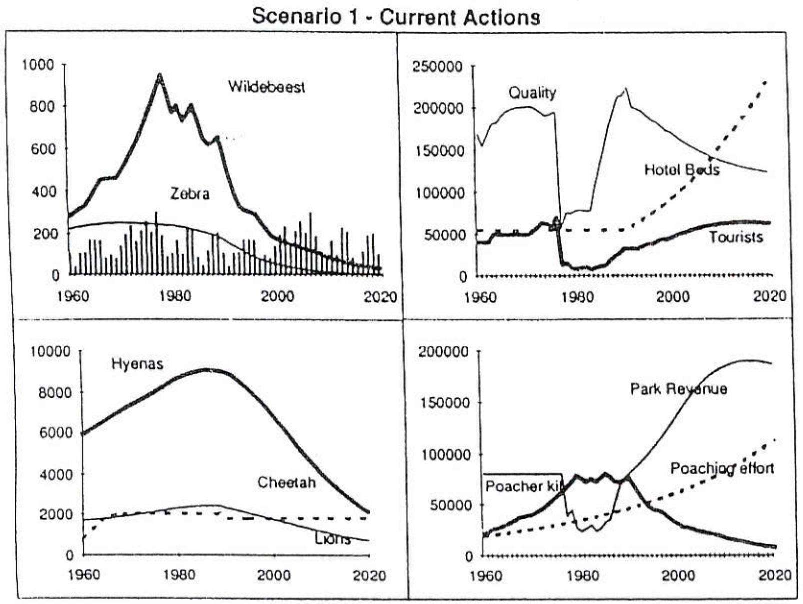

Figure 29.2 Output from scenario 1, the current situation of animal populations, park management, and poaching. Shown in upper left panel are wildebeest population (thick solid line) and zebra population (thin solid line), both in thousands, and dry season rainfall in mm (vertical bars). Shown in the upper right panel are number of tourist nights (thick solid line), number of hotel beds (dashed line), and tourism quality (thin solid line). Shown in the lower left panel are numbers of hyenas (thick solid line), numbers of lions (thin solid line), and numbers of cheetahs (dashed line). Shown in the lower right panel are poacher kill (thick solid line), park revenue (thin solid line), and poaching effort (dashed line).

declines of their own. Cheetahs are unaffected because they feed primarily on Thomson's gazelles, which are not severely poached.

Scenario 4: Poor Rainfall

In scenario 4 (fig. 29.5) we assume that rainfall after 1990 will be 66% of that seen in scenario 1. There is reasonably little difference between this scenario and scenario 1, except that the decline in ungulates is more rapid.

Scenario 5: Human Population Decline

In scenario 5 (fig. 29.6) we explore the consequences of a severe decline in the human population, a possible consequence of the current AIDS epidemic or some similar catastrophe. From the year 1990 onward we let the human population decline by 5% each year. This is rapidly reflected in a reduction of poaching effort and poacher kill, and a rebuilding of the wildebeest population.

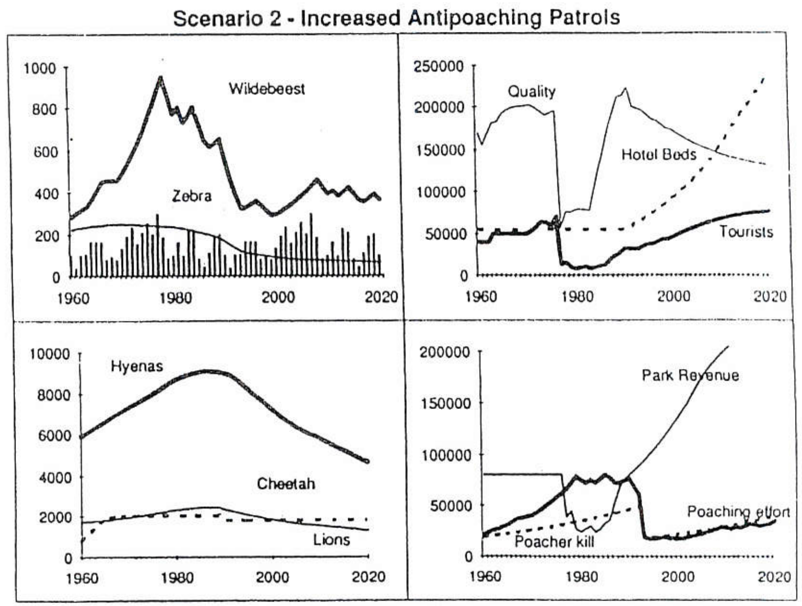

Figure 29.3 Output from scenario 2, a fivefold increase in anti-poaching patrols. See figure 29.2 for description of indicators.

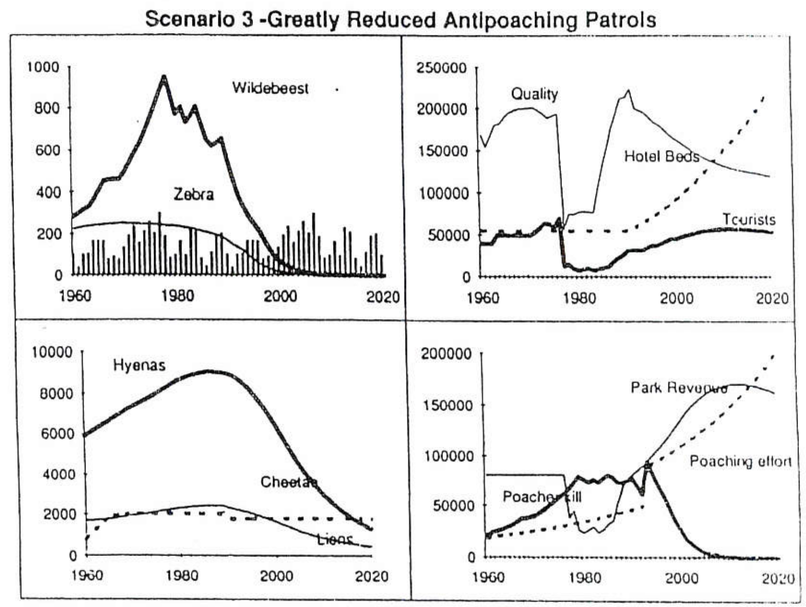

Figure 29.4 Output from scenario 3, a near elimination of anti-poaching patrols in 1990. See figure 29.2 for description of indicators.

poacher kill. The estimates we have used are tentative, and much more research is needed. Further, the effectiveness of anti-poaching patrols needs to be understood. It is clear that the wildebeest and zebra populations can withstand some level of poaching; the question is how much is too much.

Since tourism is the major source of income for the parks, we need to understand what determines the quality of tourism. This could be explored by various tourist surveys and by comparisons among different parks to see what factors are related to the number of tourists.

It is widely believed that the predators—lions, leopards, and cheetahs—are major components of tourism quality. The population-level responses of these predators are not well understood. The predator modeling group had considerable difficulty in formulating the components of recruitment and mortality necessary for predicting the effects of changes in the park.

Cautions

A final word of caution: This model does not represent the state of the art; it is merely one realization (4 days worth) of how things might work. Each individual group could build a better model. A research group could build a better combined model. This model provides a first look at how the system might work and should be viewed as a starting point for further exploration. The process of the workshop was much more important than the product.

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constitute the assessment, no two assessment problems are the same and they cannot be successfully treated with a fixed agenda. Therefore we have synthesized our experience into a "typical" scenario – flexibility and adaptability remain paramount. We have tested these procedures and are confident that they work. Specific procedures for operating the scheduled workshops are detailed in the next chapter.

January 1: The Assessment Begins

On January 1 the program manager is charged with preparing a report on the likely consequences of a major development. The report is to be completed within 1 year, and he may draw upon scientists and advisors both from his organization and from collaborating ones.

The program manager's first task is to identify the central members of his team. These fall into two groups, those who possess analytic skills (e.g., computer programming, data analysis, statistics) and the subject matter specialists, who might be biologists, geologists, economists, or engineers. The analytic group and one or two of the subject matter specialists will form what we call the *core group*. This group will run the workshops, do the computer modeling, and analyze alternative policies. The subject matter specialists outside of the core group will be called upon as their expertise is required. Workshops coordinate the activities of the core group with those of the specialists and methodologists.

January 15: First Meeting of Core Group

Before the entire team is assembled, the core group meets *in camera*, to outline the nature of the problem. This includes defining a range of management options, interest groups, and objectives. Additionally, and importantly, the core group should define the set of variables relevant to the decisions that must be made. At this meeting a first attempt is made to determine the physical boundaries of the problem, the temporal and spatial resolution required, and the level of detail the model should take. Other participants needed for the assessment groups are identified.

The products of this meeting are a list of participants for the first workshop, an understanding of the general form the model will take, and an assignment of responsibilities. The core group then begins to assemble the computer software and hardware for their modeling activities, and the specialists review the available data relevant to the problem.

The stage is now set for the first workshop. Although the core group has a preliminary definition of the problem, it is tactically important that these preliminary decisions remain invisible during the first workshop and that they be readily abandoned if it seems appropriate. In the workshop related decisions will be made again by all the workshop participants and will be modified as a consequence of the broader experience of the participants. It is important for these

decisions to be made extemporaneously – and more important that they appear to be made so. The commitment of participants to the project in future workshops depends on their self-identification as creators of the model. However, it is also important that the first workshop establish momentum and that it does not become stalled over technical indecision. It is for this reason that the core group must have a set of "shadow decisions" in their back pocket to draw upon if the workshop falters.

February 15: First Workshop (2–3 Days)

This workshop is attended by the core group and all the specialists. In addition, it is critically important that the higher level decision makers and managers be involved as much as possible. Frequently, they will be able to attend only the first day, or even only the first hour, but it is of the utmost importance that they be there even for that hour, and at least two or three should attend the whole workshop. If the person who requested the report participates in the opening of the first workshop, he knows what is happening and feels a part of it. The ultimate decision makers can so guide the initial discussions as to ensure that the exercise remains relevant to their needs. A group of biologists left alone might produce a very interesting model of a game population, but one irrelevant to the management of that species. The presence of decision makers thus provides needed guidance in the early stages of the program.

This workshop follows the general rules described in the orchestration chapter (Chapter 4). The first days are concerned primarily with defining and bounding the problem, selecting the variables, and designing the framework of the model. Unless the core group is especially experienced, it is unlikely that they can have a rough model operating by the end of this workshop. The important point is that they have all the information and materials they will need to write the computer program before the participants leave. The core group must have the model structure defined for programming and must also have the estimates, however rough, of the parameter values for this model. The subject matter specialists must leave the meeting with a firm understanding of the data that are needed for further modification and refinement of a model that can be responsive to the management questions.

Three critical steps must be completed by the end of the workshop. First, the problem must be clearly defined – management actions, key variables, spatial extent and resolution, and time horizon and resolution. This definition should have led to at least a crude outline of a model. The core group will then use this information to develop, modify, and refine the model. Second, the key data needs must be defined, and preliminary research plans outlined by the specialists for the coming field season. Finally, the person requesting the assessment must have been so involved that he and the group are assured that the relevant information will be obtained. The more he is involved interactively in this critical 2 to 3 days, the more likely that this condition will be satisfied.

were regional government planners, and some were residents of the village itself. After the workshop, one person spent 2 weeks writing a report on the results. A PDP-11 computer (28,000-word memory) was used – again a computer of a size commonly available throughout the world. The investment in time and money was small, and the payoffs were great. This type of workshop could probably be used in many short-term evaluation programs; some parallel examples are outlined in Walters (1974).

Several important problems were defined and clarified by the Obergurgl model. The initial concerns about environmental quality receded to minor significance. Of more concern was the obvious inability of the village to maintain its current style of life, which is associated with continued growth of the hotel industry. The land will run out; subsidization, taxation, and zoning changes can only alter the date. When the Obergurglers returned to their village after the workshop, they initiated a series of public discussions about the future of the village. This period of discussion reached a peak during a 1-day presentation in the village of the results of the model by the modeling group. The need for a change in life style and expectations became obvious to many of the villagers; the search for a solution began. The model could not provide a solution, but the people can. They are now actively exploring means of expanding the economic base to provide nonhotel employment, and more important, the children who are now growing up are doing so with a better understanding of their future.

ENVIRONMENTAL MANAGEMENT

It is more difficult to prescribe a generalized sequence of steps for the process of designing policies for management. In many assessment situations the institutional authority, however narrow, is at least clear and undivided, and a useful sequence can therefore be generalized. Most environmental management situations, however, are much more complex. There is often a division of responsibilities for research from those for policy design and management. In such instances, as a consequence, the research often drifts from a focus on management and policy questions to a focus on general scientific questions. And those developing policies find themselves isolated from appropriate research information either because it was never obtained or because it is hidden behind institutional barriers. Moreover, in many problems of development or resource policy design a bewildering number of agencies seem to have, or desire, some voice. Finally, policy design, more than environmental assessment, must face the conflicting objectives of different governmental, industrial, and public interest groups.

Because these problems and the cast of actors concerned will be different in different situations, the best we can do now is attempt to identify the lessons we have learned from our various case studies. All our studies have contributed insights, but the budworm (Chapter 11) and salmon (Chapter 12) work, having gone farther toward introducing concrete change within agencies, have been the major learning experience. Both these case studies give the flavor of the institutional complexity that faced us.

In the broadest sense, the steps described above for the assessment process still apply. There is, however, greater explicit emphasis on designing a range of alternative policies and on involving a larger variety of institutions, role players, and constituencies in the actual design and evaluation. As a result it takes more time, more flexibility, and more adaptive response to opportunities as they emerge.

The major conclusions drawn from our efforts to implement the process and techniques within operating agencies follow:

1. Transfer of analysis, of the process, and of techniques means more than mailing the computer codes and writing a report. It also requires a program of workshops and intense "user" involvement so that the local scientists and managers end up as the real and acknowledged experts. A measure of success is the extent to which the original analysis group becomes less and less visible and the local groups more and more visible as the program moves into implementation. The initiators' very strong and markedly parental inclinations to keep control too long must be resisted, or transfer will fail.

2. Vigorous institutional support and protection is necessary but not sufficient; the policy design approach can be transferred only to people, not to departments. Respected local leadership of the program is essential.

3. The analysis must be made fully transparent and interactive. Hence extensive use of graphic presentations (Chapter 9) and an interactive computer environment are important to allow easy examination and modification of model assumptions. Cooperating scientists and managers can therefore explore their own experience and assumptions in the context of the models and so develop a critical understanding of the strengths, weaknesses, and limitations of the analysis.

4. Communication of the results must go beyond the traditional written forms. Modular slide–tape presentations describing the approach, the problem, and the model can communicate the essential features vividly and rapidly without compromising content (Chapter 9). In the budworm study, for example, a 4-minute motion picture of space–time dynamics under various management regimes better revealed that behavior than any amount of static discussion and analysis.

5. A sequence of participatory workshops beginning with scientists, proceeding to managers, and finally involving policymakers builds a foundation of confidence and understanding. A "top-down" sequence would, by contrast, force the technical analysis group into a premature position of prominence, alienating local experts and promoting little but suspicion.

6. The final – and perhaps the most restrictive – requirement of effective transfer is time. The budworm policy analysis *per se* took less than 6 months; the full program to implementation more than 3 years. Some of this time was spent in the workshops described above and in Chapter 4, but much was an incubation

particular area of concern. Thus, a wildlife biologist might be consulted about the effects of a dam on big game animals, an economist about effects on recreation, a hydrologist about water flows, and a fisheries biologist about effects on fish. However, this approach often omits consideration of cross-disciplinary interactions, such as the effect of changing recreational demand on big game and fish populations (Walters, 1974).

In contrast, the interdisciplinary team approach exemplified by many recent research programs has attempted to promote communication among disciplines, which was lacking in the first alternative. Computer models are usually the focus of these team efforts, and because these teams involved many disciplines, the models are usually large and complex. However, it is now believed that the original goals of many of these team efforts were not met (Holcomb Research Institute, 1976; Mar, 1974; Mitchel *et al.*, 1976; Watt, 1977). The research was not significantly more integrated than in nonteam programs (Mitchell *et al.*, 1976), and models originally developed for research purposes were not necessarily appropriate for decision making (Holcomb Research Institute, 1976; Peterman, 1977a). In addition, the large number of people, large budgets ($1–2 million/year) and long time frame for project completion (~ 5 years) created an environment where studies within disciplines became bogged down in details irrelevant to the management questions, where cross-disciplinary interactions were ignored, and where group activities drifted off in different directions (Ford Foundation, 1974; Holcomb Research Institute, 1976; and Mar, 1974). Moreover, the highly complex models that resulted from these large team efforts often defied understanding by either the modelers or the client decision makers (Lee, 1973; Holcomb Research Institute, 1976).

Both the interdisciplinary team approach and the formalization of the environmental assessment process were nobly motivated efforts, often expensive and experimental because they were so new. It is the history of that experience, of successes and of failures, that has led to a thread of tested concepts and techniques that deserve broader application. The failures were both expected and necessary; that is how we learn. Since the approaches have been admirably reviewed elsewhere (Ackerman *et al.*, 1974; Council on Environmental Quality, 1976; Dasmann *et al.*, 1973; Ford Foundation, 1974; Holcomb Research Institute, 1976; Lee, 1973; Mar, 1974; Mitchell *et al.*, 1976; O'Neill, 1975; Peterson, 1976; Schindler, 1976; Watt, 1977), we will only comment that these failures appear to have been consequences of inexperience in bridging the gaps between disciplines, data, techniques, knowledge, institutions, and people.

WORKSHOPS, THE CORE OF ADAPTIVE ASSESSMENT

In contrast to the individual-discipline or large-team approaches to environmental impact assessment and resource management, we have used an approach to bridging

some of the above gaps that depends upon a small group of people that interacts with a wider set of experts during a series of short-term, intensive workshops. Most of our workshops have used the construction of a quantitative model as a focus for discussion, but as we will demonstrate later, many benefits will arise from workshops even if other predictive methods are substituted. Both the process and the product of these workshops are directly applicable to assessment and management problems.

Involvement of small teams and short time spans in these workshops circumvents the scientist's natural tendency to break problems down into components, and those components down into subcomponents, and so on. This tendency is a natural response to complexity and is deliberately encouraged in disciplinary training, especially in biology. But it is often not suitable for dealing with management concerns that are at a different level from those of the scientist (Mar, 1974) and that are likely to lie between usual areas of disciplinary interest and training. Instead, a small group of people working with a specific goal (model) in a well-structured atmosphere over a short period of time has advantages. Participants are forced to recognize that not all the components of biological or economic systems are of equal importance and that judgments will have to be made about the relative importance of the various pieces of the problem. Some details of workshops, such as size of group and budget, have already been discussed in Chapter 3.

From experience in more than two dozen cases (e.g., Himamowa, 1975; Clark *et al.*, 1977; Walters, 1974; Walters and Peterman, 1974; Walters *et al.*, 1974; Part II of this volume), we have found that small teams interacting through modeling workshops over a relatively short time can successfully carry out an assessment while addressing the three issues raised at the beginning of this section. Watt (1977) and Mitchell *et al.* (1976) have also concluded that small teams are most productive. However, success can be achieved only if appropriate people are involved at the various stages of analysis. The main participants are disciplinary specialists; methodologists who are familiar with techniques of analysis such as modeling; and decision makers who will ultimately use the information that results from the analysis.

There are obviously many environmental problems that cannot be solved without long-term studies by large research teams. But it is pointless and wasteful to initiate such studies without a clear and reliable strategy for insuring continued coordination and cooperation, particularly on issues that the individual specialists will tend to avoid. We suggest that modeling workshops can help to provide a brain for the body of the research team – they provide periodic reassessment and redirection.

We have used workshops in three ways during our studies of environmental problems. First, workshops are an effective way to begin a problem analysis, that is, to bring people together, to define the problem clearly, to examine existing data, to formulate some initial predictive scheme, and to identify future steps in the analysis. Second, workshops can form the backbone of a longer term, in-depth analysis in which alternative models or predictions are made and alternative higher level administrators, along with other participants, should be provided with a series of payoffs during the course of evaluation (Holling and Chambers, 1973). The problem analysis can often result in substantial reordering of research priorities and identification of new data requirements, a benefit to researcher and administrator alike.

The first workshop for the specialists, administrators, and methodologists can take the form of one or two 3–5-day sessions whose goal is to produce a working first-approximation model that can be used for testing alternative management or development schemes. A common reaction to an early attempt to build a model is the feeling that not enough data are available. However, we have found that if useful data are ever going to be collected in a research program, some conceptual models must exist to guide the collection. In an attempt to quantify those conceptual models, the assumptions underlying them are brought out into the open and appropriate test data are more clearly defined. Thus, with a modest amount of basic survey information and knowledge of similar systems, the first workshop can begin.

The key element of this first workshop, as well as of subsequent ones, is the small core team, in our cases made up largely by people with some background in both the methodology (simulation modeling) and some resource discipline. This group integrates the information provided by specialists and managers. If and when subsequent workshops are conducted to deepen and broaden the analysis, this core group provides the continuity of experience needed to carry on the problem analysis. For those readers that have little experience with workshops of this type, we must emphasize that most of the art of conducting them is in dealing with people, not in facility with techniques. Holling and Chambers (1973) and Walters (1974) discuss some of the "people" lessons revealed through our own experiences, but the best and quickest way to learn modes of successful operation of workshops is to build a body of experience by conducting some. A full description of the steps we have taken in first workshops, those devoted to initial problem analysis, follows.

THE WORKSHOP PROCESS

First, some management goals need to be defined; even for a development scheme there must be some overall objective. Even if the decision makers present agree on an objective, a wide range of alternative objectives should still be considered so that the model can be responsive to possible future changes in objectives (Holling and Clark, 1975). By a *range of objectives*, we mean goals as extreme and as simple as maximizing economic return from a renewable resource versus preserving the natural state of that resource. While no one of these goals would be realistic, together they would cover a wide enough range that any real objective would fall somewhere within it (Clark *et al.*, 1977). The importance of an early statement of questions to be answered by the exercise cannot be overemphasized. As Brewer (1975) points out, too many models have been built with unclear program goals, resulting in too many inappropriate models.

Next, it is necessary to identify the variables, or indicators, that the client decision makers can use to judge how well alternative management actions meet given objectives. These indicators are really performance measures, such as level of employment, number of animals harvested, or kilowatts of electricity produced. As a consequence of the identification of objectives and indicators, the problem to be analyzed begins to be bounded. Further decisions have to be made concerning the range of management actions to consider, the temporal horizon and resolution, the spatial extent and resolution, and the ecosystem variables to be included. For example, should a salmon fisheries model consider a set of management actions ranging from building of enhancement (artificial propagation) facilities down to specific controls on insurance against bad times? Should the model consider only one small fishing area and the boat movements within it, or should it consider the whole coast and movement of boats between areas? Should the model explicitly consider all species of fish that potentially interact with salmon, or should only the major salmon species be accounted for? These questions are of the type that define the problem, and their answers are, in large part, determined by the management needs established earlier. A detailed example of problem definition in the spruce-budworm/forest-management case study can be found in Chapter 11. This first step of defining or bounding the problem through indicator identification is very critical; the rest of the analysis will in large part reflect decisions made at this early stage. Too narrow a conceptualization of the problem can eliminate from consideration a perfectly viable set of management options, or lead to predictions that overlook some key management concern.

One of the main purposes of the workshop is to promote interdisciplinary communication and to focus the scientist's expertise on the real management questions that the assessment is to address. To initiate communication, we have found it effective to use a process we call "looking outward." In the usual kind of impact assessment or management design program, each specialist is asked to predict how his own subsystem, such as the fish population or the vegetation, will behave. His natural tendency is to devise a detailed conceptual or numerical model consisting of many variables and relationships that reflect current scientific knowledge within his discipline. However, this conceptual model is usually more complex than is necessary to predict the behavior of a subsystem at the level of management indicators. Worse, each narrow conceptual model usually does not consider important links with other subsystems. In the "looking outward" approach we simply reverse the standard question asked of the specialist. Instead of asking "what is important to describe your subsystem X?" we ask "what do you need to know about all the other subsystems in order to predict how your subsystem X will behave?" Thus, the specialist is asked to look outward at the kinds of inputs that affect his subsystem.

After each subsystem has been subjected to this questioning process, each specialist possesses a list of "output" variables whose dynamics he has to describe so that these variables can serve as inputs to other disciplines. These cross-transfer variables that link the subsystems are essential in describing a picture of the overall puter terminals that permit individuals to ask "what happens if . . ." questions of the model can be extremely beneficial in making model assumptions and limitations clear, in suggesting further refinements, and in revising performance criteria. Only modest investment in computer software and hardware is needed to create this important "hands-on" gaming capability (see Chapter 3 again).

SECOND-PHASE WORKSHOPS

The kind of workshop just described serves to start a problem analysis. The resulting model is clearly incomplete, and further efforts may be required to clarify data needs. The next phase of analysis can involve additional workshops, the number depending on the problem being studied. These workshops aim to revise the model and define new information needs, particularly as new data become available. In some cases a credible process of evaluation can be completed with only two workshops, held several months apart; other cases may require a series of workshops that are held over a year or two. The same mix of people, though not necessarily the same individuals, should participate in these later workshops: methodologists, specialists, and decision makers. The time between workshops is spent in data collection, model testing, and evaluation of management policies (Chapters 7 and 8), the last two activities largely being carried out by the small core team.

Again, the second phase of workshops can be equally valuable, whether participants are operating in an active, integrated policy design mode or making a relatively independent assessment of proposed policies. The value derives from the more careful focusing on critical issues, data needs, and questions. Some of these second-phase workshops were illustrated in Chapter 3.

TRANSFER WORKSHOPS

Finally, as the analysis or assessment nears completion, the phase of transfer to the contracting agency or other clients who were not involved during problem analysis begins. Here again workshops have proved valuable (Gross *et al.*, 1973; Clark *et al.*, 1977; Peterman, 1977a) in both an impact assessment setting and a resource management program. When the model is used as a focus for discussion, the assumptions underlying the analysis are clarified and the "client" decision makers can ask various questions of the model through interactive gaming. This so-called "implementation" phase is quite critical; without a smooth transition, even the best analyses are incomplete. Thus, attention must be given to the best ways of communicating the information. Chapter 9, on communication, illustrates some of the most effective ways we have found to transfer information.

FLORES

Knowledge → Sustainable Development

Forest Land Oriented Resource Envisioning System Model Design Workshop

Jambi & Bukittinggi, Sumatra, Indonesia
22 January - 4 February 1999

Workshop and Field Trip

FLORES:
... helping to answer the important questions...

Organized by :
Center for International Forestry Research (CIFOR)

in collaboration with :
Centre de coopération internationale en recherche agronomique pour le développernent (CIRAD),
Department For International Development (DFID),
International Center for Research in Agroforestry (ICRAF)
and
the University of Edinburgh

CIFOR
Center for International Forestry Research

ICRAF

CIRAD

The University of Edinburgh

DFID Department For International Development

Foreword

CIFOR, in partnership with CIRAD, ICRAF, the University of Edinburgh and with the sponsorship of DFID (ZF0104 /R7315), is holding a workshop to help design and implement FLORES, the Forest Land Oriented Resource Envisioning System. FLORES will help explore the consequences at the landscape scale, of policies and other initiatives intended to influence land use in developing countries in the tropics. It will provide an accessible platform to foster interdisciplinary collaboration between researchers and facilitate empirical tests of hypotheses and other propositions.

The workshop will be held in Indonesia during 22 January to 4 February 1999. Participants will collaborate to design, construct and test several components of the system following the participatory approach pioneered by Buzz Holling. In this workshop, the emphasis will be on capturing the interactions between human decision-making - modelled at the level of the individual household - and the surrounding land, modelled at a level approaching that of an individual field. A field trip will form an integral part of the workshop.

Dr. Jerome Vanclay
Systems Modeller

Background Information of Jambi Field Trip

Sumatra Island is 350 km at its widest, almost 1700 km long, and is cut in two roughly equal parts by the equator. A typical W-E cross section of Sumatra resembles a 1:10 scale model of S. America:

- a narrow W. coastal zone, with a long history of settlement and relatively fertile soils,
- a high mountain range (Bukit Barisan in stead of Andes) with atches of young volcanic soils and fertile valleys inhabited from prehistoric times, as well as limestone outcrops,
- a piedmont (foothill) zone with colluvial, moderately fertile soils,
- a lowland peneplain of marine sedimentary origin and leached out acid soils of low fertility, dissected by rivers in moderately fertile river beds (rivers such as the Batang Hari in stead of the Amazon),
- a gradual peat swamp/mangrove transition from wet land to a shallow sea full of sediment.

The rivers provided the main transport until the beginning of the 20'th century and typically were controlled by cities on the first high ground when coming in from the sea (Palembangon the Musi river, Jambi city on the Batang Hari, Manggala on the Tulang Bawang) and trading posts at the highest navigable point on the river where it contacts the more fertile piedmont zone which produced export crops such as pepper (the main export product of Jambi in the past...) and coffee, as well as NTFP's (various resins, rotan etc.).

Jambi Province is located in the middle of Sumatra (just S of the equator) and provides a typical cross section of the ecological zones, as it nearly coincides with the Batang Hari watershed, one of the biggest rivers of Sumatra. Some 40% of Jambi was covered by piedmont and mountain forests (dense moist evergreen) of the Bukit Barisan range. Another 40% was covered by lowland tropical rain forest and the remaining (20%) in the east area by mangrove, swamp and peat swamp forest. Over the past centuries Jambi has alternately been a separate sultanate and part of a larger power based in Palembang

A drastic change in land use occurred in the first decades of the 20'th centurt when 'para rubber' (Hevea) spread like wildfire and quickly replaced the varuious native rubbers collected as NTFP. Para rubber prices were so interesting that rubber seedlings were quickly introduced into the existing tree fallow/upland rice rotation and the forest fallows/secondary forests were transformed into 'rubber agroforests'. This transformation happened while all transport was still river-based. During the rubber boom after WWI a lot of outside labour was attracted to work as share-tappers, and part of them settled and stayed on. When the boom was over, Jambi returned to a 'backwater' position, but rubber was firmly established as the main cash

earner and basis of trade and local industry. Away from the rivers, forests remained and the 'Anak Suku Dalam' (better known under the derogatory name 'kubu') kept enough space for their specialized NTFP gathering. Intensive logging, along with major road construction projects (Trans-Sumatra highway and feeder roads) and transmigration settlements have caused a dramatic change over the past 25 years. There is hardly any lowland tropical rain forest left in Jambi, and only some of the foothill and mountainous forests are protected. The rubber agroforests have become the main reservoir for forest biodiversity, but the current trend to replace them by large-scale oil palm plantations will leave little of their current value. The mangrove zone and peat swamp has become the 'last frontier'.

In this trip, we will visit two of the 'benchmark sites' which were characterized during the first two phases of the Alternatives to Slash and Burn (ASB) project:
as part of a land use intensity gradients that typifies lowland Sumatra.

1. Bungo Tebo:
This area is a dissected peneplain, consisting of acid tuffaceous sediment, the elevation generally below 100 m.asl. The soils in this area are very deep, well drained, very acid, and have low soil fertility status. In the field trip we will visit the peneplain ASB benchmark area to see mixed fruit agroforest and jungle rubber belonging to the local people, transmigration village, degraded land dominated by alang-alang (*Imperata* sp.),

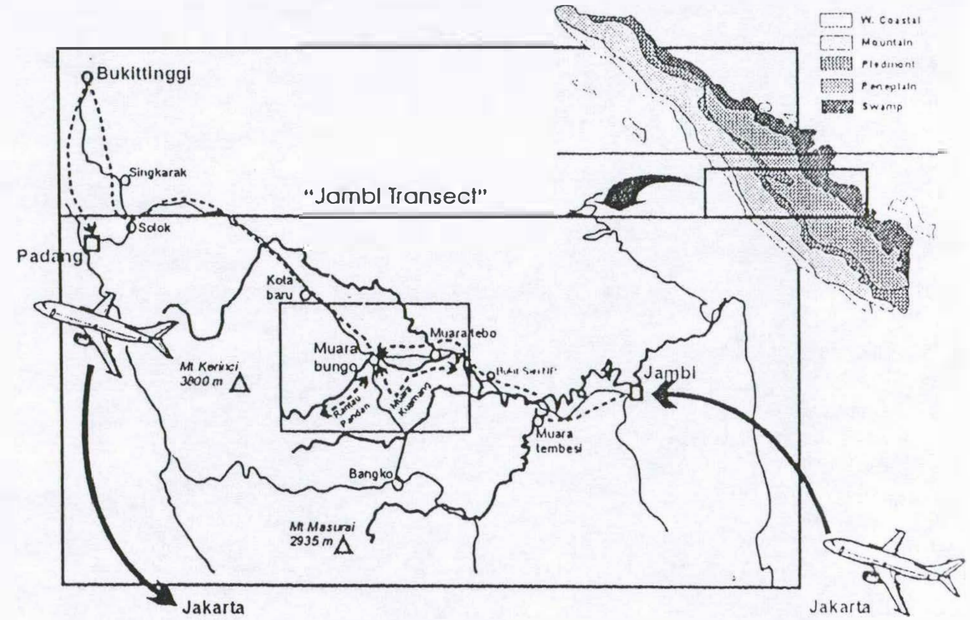
food crop base systems, a logging concession, oil palm plantation and intensively managed rubber.

2. Rantau Pandan:

This area represents the piedmont zone ranging from 100 to 500 m.asl. Soils are composed of latosol-litosol complexes with fine texture. The jungle rubber or rubber agroforest is the predominant farming system in this area. The other land use types in this area are wetland rice field (sawah), shrub land (belukar) and garden (kebun) which is usually privately owned and tradeable. The garden systems were originally from belukar or primary forest and are commonly planted with jungle rubber and cinnamon. In the field trip we will visit the piedmont ASB benchmark area to see the rubber agroforests and other land use in this area where little in-migration has occurred and where major threats to the agro-ecosystem come through the logging concessions in the hills.

Jambi trip day 1:

The field trip will start on Sunday, 24 Jan, departing from the Novotel hotel at 09.00. We will travel to Muara Bungo (250 km from Jambi) going upstream along the Batang Hari, on the way we will see landscapes dominated by rubber, a few patches of lowland forest and several oilpalm plantations and industrial deforestration. We will stop at Bukit Sari National Park for lunch. After lunch we will make a stop in the Sepungur area to see one of the ICRAF experiments on rubber agroforestry systems *(RAS)*. We will arrive at Muara Bungo late in the afternoon and stay in Swarna Bhumi hotel.



Jambi trip day 2:

Participants may select one of 3 alternatives. Two groups will go to Rantaupandan and the other group will go to Muara Kuamang in the Bungo-Tebo benchmark area.

Rantaupandan Trip 1

(Leader: Dr. Gede Wibawa /Indonesia Rubber Institute)

In this area we will visit the "piedmont" ASB benchmark area to see various types of rubber agroforest included in experiments of the Smallholder Rubber Agroforesty Project. Part of rubber agroforests are maintained on a rotational basis with slash-and-burn land clearing methods used for rejuvenation. Another part is rejuvenated at gap level and allows more chance to develop its local forest resemblance. The major threats to the agro-ecosystem come through the logging concessions up hills. The upper reaches of the valley adjoin the Kerinci Seblat National Park, and further expansion of villages is no longer possible. A final stop will be at the Rantaupandan waterfall to see a small remnant of the original forest preserved as nature reserve. We can climb up along the waterfall to see one of the ASB survey sites.

Rantaupandan Trip 2 (Leader : Dr. Chris Legg / EU Forest Inventory and Management Project)

In this area we will visit the EU Forest Inventory and Management Project which is located near Sungai Telang to see a range of agricultural practices, from sawah (irrigated by wheels in places) through fruit groves and forest rubber to new ladang. We will hopefully be able to see the forest edge in the middle distance how cultivation, traditionally confined to the valleys, is gradually spreading up steeper slopes. We will then drive slowly back to Muara Bungo, stopping 3-4 times to see traditional villages, smallholder rubber, the effects of natural barriers (river Bungo) and a village market (hopefully active so the range of produce can be seen). Participants will have satellite images and vegetation maps from FIMP (one between 2 persons), and will be shown the use of GPS in position fixing for ground-checking maps and images. They will also have extracts of the FIMP socio-economic database for all villages that we visit, and there will hopefully be discussions of differences between villages (access, distance from forest, extent of valley land etc).

Muara Kuamang Trip
(Leader: Dr. Meine van Noordwijk / ICRAF)

We will visit the peneplain ASB benchmark area and see four types of 'actors': local people with their rubber agroforests, rejuvenated by slash-and-burn or by gap replanting, long term spontaneous migrants, settled in the 1920's and combining wet rice fields with more intensive rubber production, government sponsored transmigrants from about 20 years ago and the large-scale oil palm plantations developed in conjunction with these villages.

The agenda of FLORES Model Design Workshop
22 January - 4 February 1999

Friday, 22 January (Day 1):

14.35: All participants are expected to arrive in Jambi, Central Sumatra. Most participants will arrive directly from Jakarta by Mandala RI 022. We will stay at Novotel Hotel in Jambi.

19.00: Welcome party for all participants.
Venue: Conference Room 2nd floor Novotel hotel

Saturday, 23 January (Day 2):

07.00: Breakfast

08.00: Introductions! FLORES Concepts
(venue: Telanai Pura)

10.30: Coffee break

11.00: AME and pFLORES

13.00: Lunch (Coffee Shop Mayang Mangurai)

14.00: Fish Banks game (venue: Telanai Pura)
AME Tutorial, max 6 participants (Kuala Tungkal Room)

19.00: Dinner (Coffee Shop Mayang Mangurai)

Sunday, 24 January (Day 3):

07.00: Breakfast

08.00: Participants check out from the hotel.

09.00: Travel to Muara Bungo (250 km from Jambi).
Lunch at Bukit Sari National Park.
Overnight in Swarna Bhumi Hotel

19.00: Dinner at Pondok Bambu restaurant

Monday, 25 January (Day 4):

07.00: Breakfast at Swarna Bhumi Hotel

08.00: Field trip to Rantaupandan and Muara Kuamang area
Picnic lunch in the field for each group.
Dinner at Lake Singkarak (235 from Muara Bungo) on the way to Bukittinggi. Stay in Pusako Hotel during the workshop.

Tuesday, 26 January (Day 5):

07.00: Breakfast

08.00: Issues and Options for FLORES (Dang Tuanku Room)

10.00: Coffee break

10.30: Model Framework and Submodel linkage

12.00: Lunch

13.30: Discussion

19.00: Dinner at Pusako Hotel

Wednesday, 27 January (Day 6):

07.00: Breakfast

08.00: Team work on submodels

12.00: Lunch
Coffee and tea are available throughout the day.
Dinner at venue of your choice

Thursday, 28 January (Day 7):

07.00: Breakfast

08.00: Team work on submodels

12.00: Lunch

Coffee and tea are available throughout the day.
Dinner at venue of your choice

Friday, 29 January (Day 8):
07.00: Breakfast
08.00: Team work (working prototypes are expected by evening of this day).
Coffee and tea are available throughout the day.
Dinner at venue of your choice

Saturday, 30 January (Day 9):
07.00: Breakfast
08.00: Team work on submodels
Coffee and tea are available throughout the day.
Dinner at Pusako Hotel

Sunday, 31 January (Day 10):
Today is a rest day for most participants. Robert Muetzelfeldt and Jasper Taylor will link the submodels and get them working. Some of you might need to finalize submodels or write documentation. We will organize city tour for those interested in sight seeing in Bukittinggi, or in shopping. Please contact Nining or Kim for registration.

Monday, 1 February (Day 11):
07.00: Breakfast
08.00: Using the completed model
10.00: Coffee break
10.30: Validation, testing feasible scope

12.00: Lunch
13.30: Model strengths & weaknesses
15.00: Coffee break
15.30: Discussion
19.00: Dinner (own choice)

Tuesday, 2 February (Day 12):

07.00: Breakfast
08.00: Discussion of workshop experiences
10.00: Coffee break
10.30: Need for further work
12.00: Lunch
13.30: Role of regional workshops
15.00: Coffee break
15.30: Discussion
19.00: Dinner (own choice)

Wednesday, 3 February (Day 13):
07.00: Breakfast
08.00: The way forward, future plans, ,
10.00: Coffee break
10.30: Potential donors
12.00: Lunch
13.30: Model applicability in different regions
15.00: Coffee break
15.30: Continuing discussion
19.00: Farewell Party at the hotel

Thursday, 4 February (Day 14):
07.00: Breakfast
09.00: Go to Tabing airport in Padang
Participants travel home (by Mandala RI061 at 1245)

Useful information for all participants:

1. *Facilitator workshop:*
   a. Jerry Vanclay (Team Leader)
   b. Robert Muetzelfeldt
   c. Harmut Bossel
   d. Robert Muetzelfeldt
   e. Martyn Murray

2. *Video Documentary:*
   a. Richard Carroll
   b. Dominic Bridges

3. *Journalist:* Stuart Blackman

4. *Support team during the workshop:*
   a. Jasper Taylor (support AME)
   b. Yuliardi Yusar (Computer specialist)
   c. Nining Liswanti(Logistic, Ground Transport, Field trip organizer)
   d. Ratna Akiefnawati/ICRAF (Local field trip organizer)
   e. Cut Fathiah Gathom (Fax, Xeroxcopy, Typing, Travel Expenses)

   f. Meilinda Wan (Typing, Accommodation, Meeting Arrangement)

5. *Confirmation Ticket:*
   Please confirm your ticket accordingly to the Pusako Hotel Travel Agent:
   a. Mrs. Herlina
   b. Mr. Piter

6. *Perdiem & Travel Expenses* (only for participants who are paid by CIFOR)
   a. Perdiem: During our stay in Jambi and Bukittinggi, we will give perdiem (dinner and incidental only) in advance. Please feel free to choose your own meal in the hotel or you might try a local food outside the hotel. Contact person: Nining Liswanti
   b. Travel expenses: If you have travel expenses, we will reimburse your travel expenses and transfer to your personal account. Please give your receipt and detail account number to us.
   Contact person: Cut F. Gathom

7. *Other important information*
   a. We will cover all the cost of dinner including soft drink, juice and beer for all participants on the following date:
      - 22 Jan: Novotel Hotel
      - 24 Jan: Muara Bungo
      - 25 Jan: Lake Singkarak

Proposed Teams during the workshop in Bukittinggi

No	Description	Institutions & Country
	Crops-Soils-Water Team	
1.	Meine van Noordwijk	ICRAF, Indonesia
2.	Robin Mathews	Cranfield University, UK
3.	Peter Jones	CIAT, Colombia
4.	Fergus Sinclair	University of Bangor, UK
5.	Attachai Jintrawet	Chiang Mai University, Thailand
6.	Stephan Weise	ICRAF, Cameroon
7.	Betha Lusiana	ICRAF, Indonesia
8.	Pornwilai Saipothong	ICRAF, Chiangmai
	Trees & Forests Team	
1.	Mike Spilsbury	CIFOR, Indonesia
2.	Ravi Prabhu	CIFOR, Indonesia
3.	James Gambiza	University of Zimbabwe, Zimbabwe
4.	Nur Masriptin	MOF & Estate Crops, Indonesia
5.	Chris Dake	Massey University, New Zealand
6.	Bruno Verbist	ICRAF, Indonesia
7.	Oscar Garcia	INIA, Spain
	NTFP-Biodiversity-Fauna Team	
1.	John Poulsen	CIFOR, Indonesia
2.	Sonya Dewi	CIFOR, Indonesia
3.	Philip Nyhus	Sumatran Tiger Project, Indonesia
4.	Paul Vantomme	FAO, Italy
5.	Allan Watt	Institute of Terrestrial Ecology,
6.	Doug Sheil	UK CIFOR, Indonesia

No	Description	Institutions & Country
	Household and Village Decision-making Team	
1.	Francois Bousquet	CIRAD, France
2.	Chimere Diaw	Yaonde, Cameroon
3.	Carol Colfer	CIFOR, Indonesia
4.	Martine Antona	CIRAD, France
5.	David Thomas	ICRAF, Chiangmai
6.	~~John Palmer~~	~~DFID, UK~~
7.	Thomas Evans	Indiana, USA
8.	Laxman Joshi	ICRAF, Indonesia
9.	Mandy Haggith	UK
	Corporate decision-making and Client issues Team	
1.	Philippe Guizol	CIFOR, Indonesia
2.	Bob McCormack	CSIRO, Australia
3.	Daniel Murdiyarso	ICSEA, Indonesia
4.	Katherine Monk	Gunung Leuser NPark, Indonesia
5.	Gede Wibawa	Rubber Research Institute,Ind.
6.	Mohd Noor bin Mahat	FRIM, Malaysia
7.	Chris Legg	EU - FIMP, Indonesia

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11.	David E. Thomas	ICRAF Chiang Mai University, Chiang Mai, THAILAND Email: d.thomas@cgiar.org Tel./Fax.: 66 53 943 799 or 806 993
12.	Dominic Bridges	FELT 1 Sans Walk, Clerkenwell, London EC1R 0LT, UK Email: felt.london@dial.pipex.com Tel.: 44 171 336 6824; Fax.: 44 171 336 6825

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16.	Gede Wibawa	Pusat Penelitian Karet Sembawa Balai penelitian Sembawa. Jl. Raya Palembang – Sekayu Km 29, Kotak Pos 1127, Palembang, Sumsel 30031 Email: irri-sbw@plg.mega.net.id Tel.: 0711 312 182 (Home: 711 316 803); Fax.: 0711 361 793
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HOUSEHOLD MODEL DOCUMENTATION

1 Background context

- FLORES requirements : weekly time step ; spatial unit : a plot ; only one owner per plot (a single relationship between an household and a plot) ; household level for decision-making, village level aggregation ; modelling of a specific regional Indonesian situation.

- Summary of basic information on individual, household and village behavior (see Annex 1):
  - household decision on activities related to land use on a short and long term basis
  - economic factors related to these decisions
  - population issues related to these decisions
  - tenure and social issues related to these decisions.

There are three primary aspects influencing decision making at the household level:
1. Population dynamics within household influencing labour availability, food requirements, etc
2. Economic parameters including material flow in and out of store, and use of the income
3. Household land management decision making process

These aspects were addressed by developing separate components for each aspect which were later combined to form a larger household decision sub-model. (An outline diagram of the sub-model would be useful here). The three components of the sub-model are briefly described in the following sections.

Population dynamics
- A population growth model is used to generate the amount and type of labor available for each household.
- This model generates the (integer) number of household members in the following groups: children (age < 15), women and men (15 >= age < 45), and seniors (age >=45) according to specified mortality and fertility rates.
- Men and women are differentiated at adult stage because their labor contributions to land management activities differ (e.g. 1 days work by a man will produce different results than 1 days work by a woman)
- The number of households is static, no new households are created (in-migration, segmentation), and no households can leave (out-migration). Thus the concept of an extended family is needed. With successive time steps, the number of members in each household grows while the number of households stays constant, so the number of members per household increases. Conceptually, these members may exist in multiple physical households but for the FLORES model they are associated with a single household which is the decision-making unit.
- The amount of child, female, and male labor is calculated by subtracting the number of members who may have left the labor pool to pursue education (a result of the education policy lever). This result is passed to the sub-models with labor allocation components.

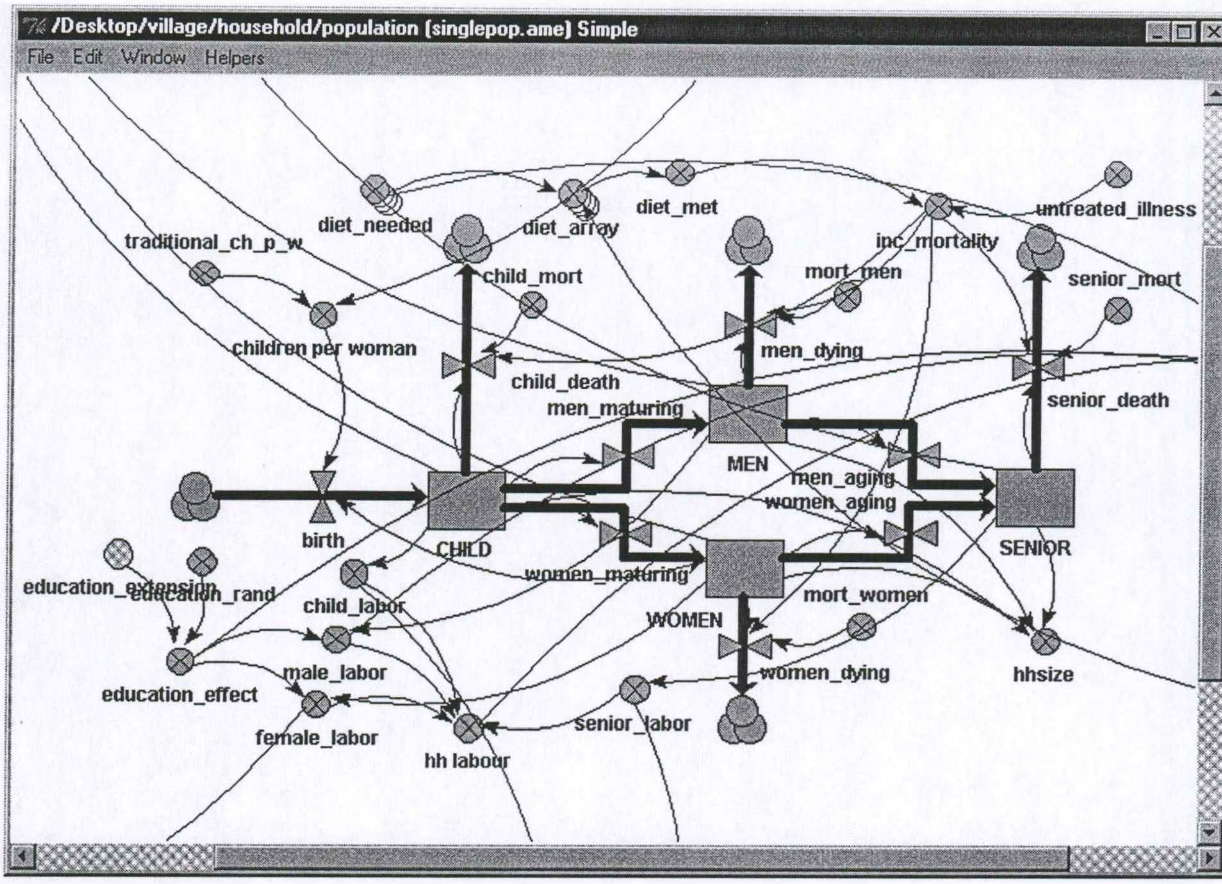

Figure 1.1 - Population Sub-model

Economic component

- The corporate/client group requires economic indicators to be produced by the household submodel (within the economic submodel). These indicators are produced at the household level and aggregated to the village level (the level at which the corporate/client group was working).

- .In order to fit with a weekly basis, the household costs of production and consumption must be taken into account within the same week with the production and off farm income the next week. It implies a two period model. So a first sub-model was built that takes into account the quantities produced, sold and consumed (*stock sub-model*). A second one uses the outputs from the first to calculate income (from sales and off farm labor) and expenses (food consumption, other expenses, input costs) and debt or investment. Prices, wage rate are fixed externally (exogenous).

- Consumption is set at a « subsistence » level (not dependent on relative price). That is to say that with higher income from agricultural production, consumption will not increase. The excess will be devoted to reduction of debt or investment. In this framework, we assume that education and health are not dépendant on income but on the population model. So households with insufficient income are indebted for education. Inability to pay healthcare costs results in higher mortality.

- Inputs (costs of production) are dependant on income. The input expenses are deducted from income after immediate food expenses, education and healthcare costs are deducted. When income is not sufficient to cover household input expenses the household activity (e.g. clearing or stomping) is not a possible decision in the land management sub-model for that time step. The remaining income (surplus) is devoted to investment (buffalo and other livestock).

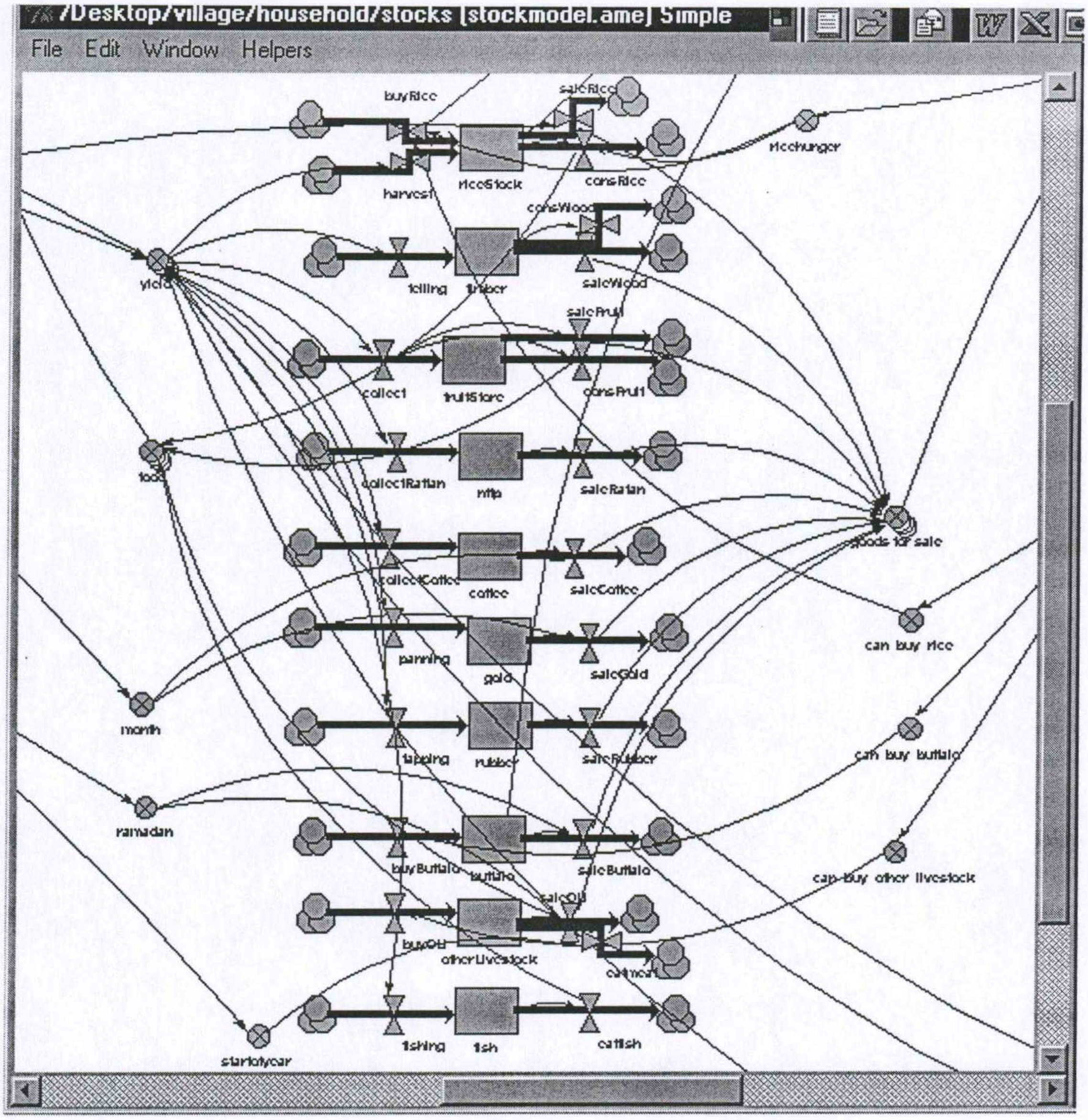

Figure 1.3 Stocks Sub-model

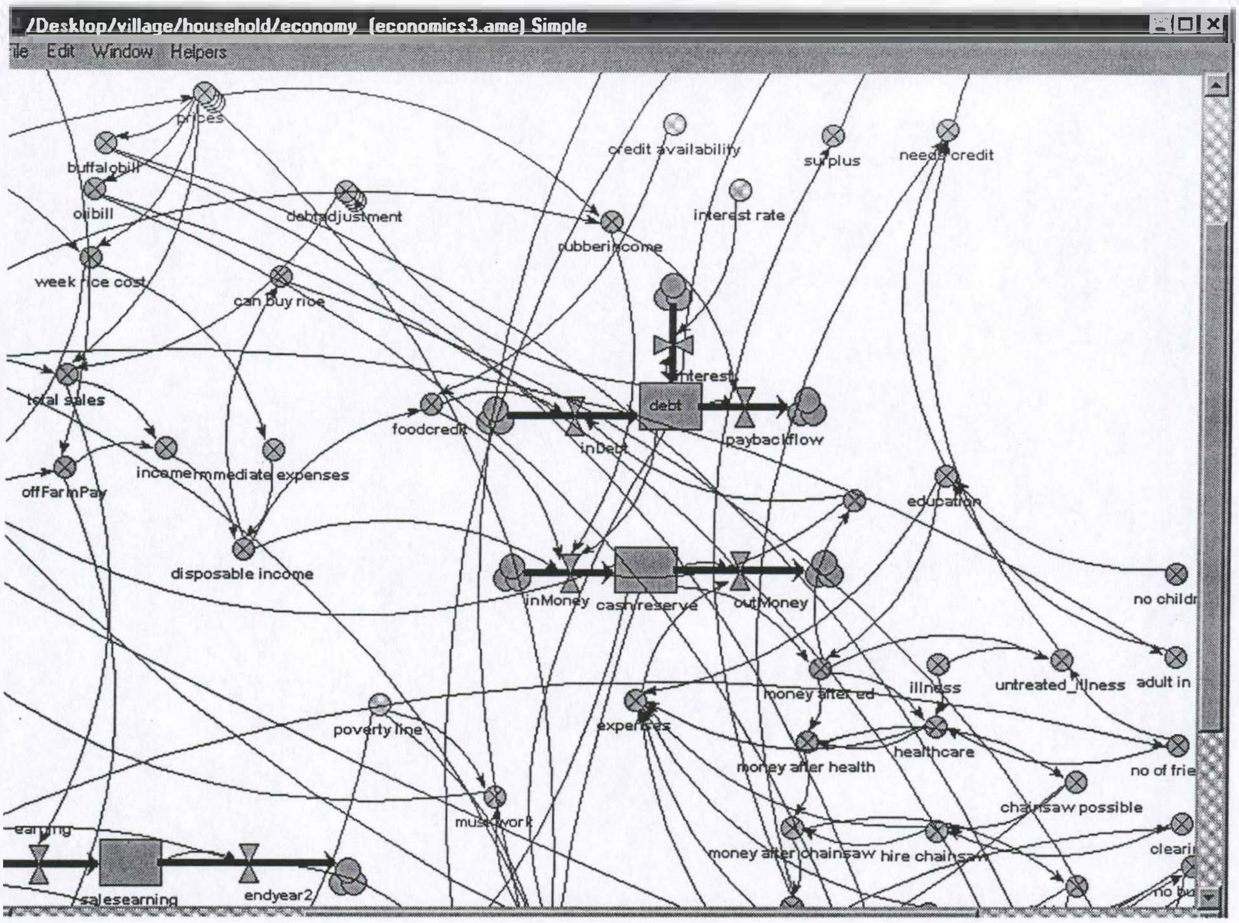

Figure 1.2 Economic Sub-model

Household land management decision making

There are two possible approaches. One is to have households allocate labour according to the demands of its production environment. This implies a kind of computational household that calculates and optimizes resources, including labour. The second one is to have households allocate labour by season, labour availability and main priorities. This implies a household whose behaviour is adapted to its environment and therefore the people have some settled idea of what to do. Since the site selected has a quite low level of market integration, the group chose to try to implement the second approach.

We first imagined the perceptions of the household about their activities (work). There are conditions on the state of the environment/plots and there are conditions on the state of the household. By combining those two conditions, we calculate the feasibility of the various activities. With regard to land preparation for upland rice, for instance, there are conditions on the plot (such as the yield is less than 100 kg/ha/yr and the age of the rubber is young) and there are conditions on the state of the household (such as total labour is more than 2, or cash stock is more than Rp. 300,000 eg. The cost of hiring equipment such as chainsaw or buffalo).

There is a set of specialized activities, leisure and childcare, which do not require decision-making within the model. There are also non-specialized activities, which require decision-making, for which rules have been written. The feasibility of the activities is tested. These refer to conditions on the plots, for example the state of the forest for logging activities. Variables have been created at the plot level on the plot objects. For each potential activity, these variables can have a Boolean values (0,1--- the sub-module is called "*possible rules*"). This also refers to conditions on the household state (e.g., the quantity of money). The same set of variables has been created at the household level. The sub-module is called "*able rules*". These two sets of Boolean values are combined to define which activities are possible and where. The variable of the household objects is called "ables".

We then imagined the actions and the allocation of time to those actions. It was necessary to estimate these allocations for a number of conditions, both household and environmental. These included season and related labour requirements; labor typically performed by men, women, children or old people; and other household conditions like amount of cash available or claims on particular plots of land. These kinds of conditions are linked to the perceptions described above and to the feasibility of those actions.

From these conditions, we defined a distribution of activities that were then fed to the concerned plots. Thee activities were identified as critical to land use management, household income and labor. This distribution is defined by proportions of activities allotted to particular tasks (e.g., land clearing, weeding) by particular categories of people (e.g., men, women) multiplied by the number of people in each of those categories within the household available to work. Nineteen tables of allocation of time have been written as a variable called "rel tables". Priorities for productive labor were set for the household (rice, rubber, casual off farm labor and NTFP collection in decreasing order of importance). This amount of time is multiplied by the labor (men, women, children and seniors), and combined with "ables", yielding "patch labor" within the sub-module. That is an array of activity, plots and amount of labor. The resulting activity, called "patch labor" (between the household and patch sub-modules) is the main output of the overall model of household decisionmaking, for the household's interaction with landscape dynamics.

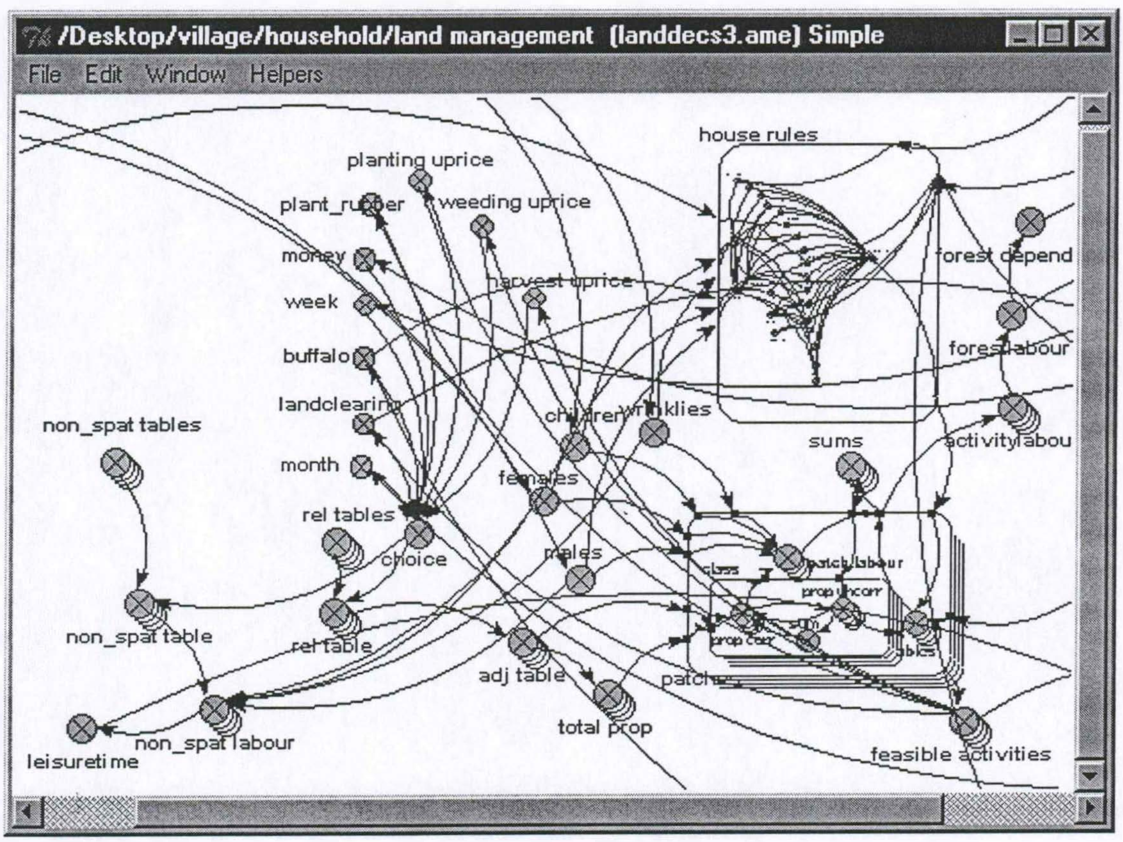

Figure 1.4 Decision Making Sub-model

2. Compromises

Spatial Scale and field-based model

- The number of ethnic groups (and hence systems for resource use) has been reduced because of the choice of site.
- Plantation agriculture, transmigration areas, roads, rubber projects were largely removed from our consideration by our choice of sites.
- We could not deal with home gardens specifically because the plot size we had selected was 1 ha and home gardens are smaller (we made them part of the village landscape)

Temporal Scale

- We also wanted to have some long term decision making (strategic decisions), but we have not been able to devote much time to this (decision on where/how to do rubber cultivation, whether to send kids to school, whether to have more children, buy a motorcycle, etc.).
- The household has only one decision strategy. The modelling of changing strategy for land use overtime was not included, because events and decisions related to other time path seemed difficult to implement (memory).

Household Level

- We had to reduce the number of categories of actors to one (from village, clan, household and individual to household only).
- The specifics of tenure and use rights were grossly simplified because we could only deal with households and because the idea of multiple families holding rights over one plot of land seemed difficult to implement with AME.
- The need to have a fixed number of households has meant that our population model has had to be modified (and simplified and made less realistic than initially imagined). This aspect should also include something on decision-making about child bearing.
- Our inability to deal with lots of NTFPs (including wildlife, fish, fibres, foods, medicinal plants) and minor vegetables means that we cannot make good estimates of labour allocated, yields per unit effort or yields per ha.

AME Specification and Linkages

- We had to reduce the number of NTFPs, vegetables and other minor crops to just a very few because of the huge number. Both of these factors reflect the diversity in the local system that serves risk reduction and environmental conservation functions. We would like to be able to reflect this better in the system. The absence of these minor products (NTFPs and minor crops) means that we have under-valued, in a way, the subsistence aspects of the local system.
- We originally wanted to include a number of qualitative issues like gender inequity and human well being, but could not figure out how to include them without complicating the model.

- We wanted to include issues relating to labour sharing, like having adjacent plots and trading labour. Although we've had some success at that, it is something we feel needs further refinement because it needs a link between two different households and a plot.

- We had to remove rivers, shared pastureland, shared areas for food cultivation of households in trouble---because we could not deal with shared ownership or village ownership

- The fact that the area was long settled means that the total area is probably claimed almost certainly by the village and almost equally certainly by households (including the forested areas). But we had to make an area a pool of forest, because of the wishes of the NTFP/biodiversity group.

3. Points left out

Tenure issues/social relations (see annex 2)
Changes in technology
Response to prices
Response to income level (income effect)
Strategic decisions
Plantations/ transmigration
Individual decision eg. Migration, /age/ tracking education
Response to rainfall (seasonality, variation year to year)
Surplus to other investment than livestock
Level of maximum debt.

4. Research development needs

Better integration between economic and anthropological approaches to decision-making (e.g., norms, market issues)

Different decision-making sets of rules for different ethnic groups (and their interactions)

Better integration of people's use of NTFPs and biodiversity/sustainability issues

Addressing these issues in more market integrated areas, especially response to price and income levels.

Improving our ways of implementing strategic decisions (like childbearing, higher education and investment in technology) over the long term and with time lags (perhaps using Prolog).

Develop way to deal with multiple relationships between households and plots. (Many-many, e.g., sharecroppers who get no return because the owner is the only one related within the model to the plot)

Improve ability to change relationships (e.g., plot sizes, household segmentation, tenure relationships)

Annex 1.

Information about household context

The following chart gives some information about the context of the households in consideration. All households are farmers practicing subsistence farming. Many farmers have both upland (*ladang*) and lowland rice and majority of farmers also has *kebun karet* (jungle rubber gardens). Latex from these rubber gardens is an important product of the system and main source of household income. Slash and burn (cyclical agroforestry system) has been a traditional system in the area. A few households adopt the system of a permanent agroforestry system (locally known as *sisipan)* where over-mature and senescing rubber trees are gradually replaced with planted or retained rubber tree seedlings inside an existing rubber garden.

Level	Decision	Household	Economic factors	Population and social constraints, others
Individual Local	Migration non seasonal	move	Off farm wage labor opportunity, subsidy	Social cost, schooling, risk aversion Land conditions
	Land use – long term	Household decision		
	Land use – seasonal	Open new land, plant rubber	Availability of land, distance, access to land, off-farm wage labour opportunity, equipment (chainsaw)	Family preference/friendship Illness and human constraints (male) Land conditions
		Plant food crop, weeding	Food security	Illness and human constraints (female) Land conditions
		Harvest rubber Collect forest products	Equipment, household needs	Tenure rights Rubber state
Individual transmigrants	Migration	Join the program or not	Land yield, current income, poverty level, subsidies	
Household local	Migration	Move	Yield income< 0	Attraction of city
	Land use - long term	Rent land to factory	Yield income<0, Regular Income opportunity	
	Land use – seasonal	Open rice field	Labour, chainsaw Household needs, distance from road	Obligation, tenure rights
		Burn		Co-operation from other/ neighbors, Rain dryness of slash.
		Plant rubber	Labour, anticipated prices, distance to market, demand	Soil fertility, marketing constraints, seed provided, government prescriptions
		Collect	Labor availability Intended use/sales	Rights on tree/land
Transmigrants	Migration/transmigration scheme	Join/abandon	Land availability, poverty, subsidies, yield	
Village	Migration non seasonal	move	Shortage of nearby land	Attraction of city – consumer goods, religious difference
		Accept settlements	Labour availability	Patriotism, pressure, transmigration schemes.
	Land use long term	Participate in government rubber scheme	Opportunity cost production losses Income/labour	Modernity
	Land use short term	Sells out and be worker	Off farm wage labour opportunity	
		Hire labor and not planting	yield	
		collect	Distance (cost of transport), availability of labour and rights	Tenure Rights
Transmigrants	Transmigration program	Join		Natural disaster; development project

Annex 2

Discussion of issues deriving from simplification of the modeling effort

1. **Unit of Analysis: the household.**
   We had to reduce the number of categories of actors/agents to only one (the HH). Individuals, clans and villages were not explicitly modeled.

   We are not sure that the sub-model allows for effective differentiation among HH types and behavior. If not, what we really have is a proxy for village level decision-making (assuming a relatively homogenous HH structure). Theoretically, it should be possible to have several sub-models, each defining a 'type' of HH behavior. Presently, however, there is no differentiation of the actors on the basis of strategic behavior or specialization.

   Effective village-level decision-making depends not only on HH behavior, but also, to a significant extent, on lineage/clan/village decision-making bodies. The effects (not the determinants) of such decisions could be inputted into the HH model, but that would require additional alternatives/ choices/ rules in the HH sub-model.

   The household was initially defined on the model of a nuclear family (wife, husband and children), reflecting available information on HH structure in the study area. With the incorporation of 'seniors' (stimulated by the population model), this has turned into a loosely defined 'extended family'. Other, more complex types of HH structure exist both in the region and in other tropical areas and should be considered. These issues have a bearing on the population model (see below) and on several aspects related to the social distribution of resources and to decision-making.

2. **Population model: the household.** Population growth resulting in an unchanged number of HH is a very unrealistic assumption. The HH decision making had to be adapted in order to meet that requirement.

   The population growth model operates on a fixed set of HH. This results in the emergence, overtime, of an equal set of undefined 'extended families'. Let's recall, at this point, that the HH model was initialized (t_0) with a nuclear structure. In t_n that latter turns into a very different social entity, without a corresponding change in the way it is making its decision (it acts as a lineage making decisions as if it was an HH, or as several 'HH' making decision as if they were just one).

   We, therefore, do not have an incorporated, credible mechanism for social segmentation as it relates to decision-making. Realizing that is essential. There is an unresolved conflict between the implicit structure of segmentation in the 'nuclear family' model (new HH are created at each generation) and the 'fixed number of households' in the population model. A choice between the two is needed within the present model. A method to segment HH according to the structural dynamic of the society under consideration (a new decision-making unit appearing at the 3rd or 4th generation, for instance) should be incorporated in subsequent versions of FLORES, as these differences have a considerable impact on decision making.

3. **Migrations: The population model.** It could be possible to artificially maintain the assumptions of both the population and HH models by sending all the excess population into migration [This may be happening in already saturated systems – as, we have been told, in some parts of Nepal. In our case, this option is more useful as an indicator of how much we need to work things out more realistically].

   The population model does not provide for **out migration**. This means that ***merantau***, systemic male migrations common in these areas cannot be modeled. **Immigration** is also not allowed. Migration decisions in real life are often made by individuals endowed with a range of characteristics rather than by whole households. The existing HH model only considers decision at the HH level. Finally, there is no provision/sub-model for **transmigration.**

4. **Scales: One-week time steps.** This puts a limitation on the type of management decision that can realistically be simulated, particularly those not related to gross amounts of time allocated to various activities but to their ***timing***. It is easier to allocate time within a week than to choose among activities which may conflict in terms of daily, hourly, or even successional requirements. This can be critical if the

issue is to improve/change farming methods, to implement an NTFP domestication program, etc. This leads to a larger 'fixed knowledge' problem and to the lack of strategic choices.

It is similarly difficult to handle **different timeframes** for economic decisions. This is particularly lacking for investment decision and decisions that reflect **long term commitments**. There is an important 'memory problem' that needs to be resolved (see also 'strategy' below).

Resolution: activities. Some activities (such as fencing in new rubber plots, for instance) could not be sufficiently separated and had to be lumped into another activity's timetable (guarding or land clearing, for instance).

More resolution needed also in relation to **capture fisheries** (including bioecological dynamics, technological responses and catch – size, composition, etc). Connection diet, health, population, income... **Idem for fish farming** (includes management requirements for different technologies, different management option, etc.).

Scales: plot size/activities. We could not deal with home gardens specifically. FLORES uses a 1 ha spatial units while home-garden areas are smaller. Multiple landowner classes not being possible, the only option left was to include home gardens as a non defined part of the village landscape.

5. **NTFPs: resolution.** We had to limit the number of NTFPs in order to simplify the model and because handling the very large number of concerned products was not feasible given the time and information available.

   Our inability to deal with several NTFPS (e.g., wildlife, fish, fibers, foods, medicinal plants) and major vegetables means that we cannot make good estimates of labor allocated, yields per unit of effort or yield per ha.

   We had to reduce the number of vegetables and other minor crops to almost none. Both reflect the diversity in the local system that serves risk reduction and environmental conservation functions. It would be useful to include such elements in subsequent version of FLORES.

   The absence of most NTFPs and minor crops means that we have undervalued the subsistence (and maybe cash income) aspects of the local system. In addition to their nutritional role, NTFPs (filtered by indigenous knowledge and social networks) play an important role in maintaining the health status of HH. Their influence in that respect may be as important as 'income' which is the main variable presently considered.

6. **Sites selection: some implications**. Given the area chosen in Sumatra, factors related to ethnic diversity and ethno-cultural orientations, with regards, in particular, to the systems of resource use have not been modeled. These are critical for national-level decision-making and should not be underestimated in future versions of FLORES.

   Transmigration areas, plantation agriculture, roads, rubber projects could not be accounted for in the model, as they are not present in the chosen study site.

   It appears that structural changes in local societies may have been taking place at a different pace in different part of the larger area. Does the model allow for capturing those changes/paths in the future? This is a general question, applicable to the whole issue of replicability, robustness, etc., of the model.

7. **Tenure**. It could be useful to develop a generic model of land tenure including the root principles of different customary tenure systems across space and time as well as the basic tenure principles of a full market economy. This is probably feasible. It could help track down the feasibility/impact of tenure-related decisions at different scales (including national/local policies & HH/lineage decision-making).

   In the present model, the specifics of tenure and use rights were grossly simplified because we could only deal with HH and because the idea of multiple claims over one plot could not be modeled.

We had to remove rivers, shared pastureland, shared areas for food cultivation of needy HH – because we could not deal with shared ownership or village ownership. In other words, Common Pool Resources (**CPRs**) are not in the model.

Because the study site has been settled for a long period of time, it is very likely that there is no unclaimed/frontier land in the area. The claims on forested areas may involve villages (whether in common or individually needs to be clarified), HH and/or groups of HH/Lineages... But we had to make an area an open pool of forest because of the wishes of the NTFP/biodiversity group. In other word, **Open Access** has been forced into the model.

It seems urgent/critical to resolve the question of representing nested rights, and nested social dimensions in AME.

We were not able to model **sharetapping and sharecropping**, since several households cannot be represented in a single plot. In the present situation all yields go to a single HH (the tenant). In a rubber production system constrained by labor and build upon a sizable proportion of share tenancy. This limitation makes this production system very unrealistic.

8. **Labor**. We wanted to include issues of labor sharing, such as the trading of labor between landholders and adjacent plots. Although we've had some success at that, it's something we feel needs further refinement.

   Sharetapping and sharecropping: In addition to the modeling constraint, we do not have the information on cost sharing nor do we have the relative distribution of sharing systems (2/3-1/3 vs. 50/50). If the above constraint is lifted, we will need to include those variables in the economic model for more valid/accurate cost-earning figures.

   A particular problem is handling how working on land belonging to another HH results in yields accruing to the sharecropper/sharetapper HH.

9. **Strategic choices**: long term decision making. This was to be partially included into the model (through choices such as deciding within a 6-9 years timeframe whether we will be able to clear new land down the road or whether sisipan would be our best option), but was not, finally, during implementation. On the whole, we haven't been able to devote much time to this [decision on where/how to chose production systems, migrate, have more children, send them to school, buy capital equipment, etc.

   We also need some way of addressing/representing anticipation.

The problem of long term memory (already raised above) is key to the strategic choice issue. Short term: how land management decisions early in the season affect decisions later in the year; long term: e.g., what are the effects of decision strategies, how to address investment without memory and with a fixed knowledge base. The fixed set decision rules for land management does not allow for learning or for adjusting decisions on the basis of feedback. It also does not allow for choices to adopt an alternative set of rules for decisions – i.e. change in strategy.

10. **Social networks,** Relations among people --- e.g. kinship, friendship, interlinked economic/social transactions, trading stocks between HH and individuals, favors to friends, mutual protection against wild pigs, etc., leading to joint strategic decision and collective action. Social networks can be used to predict the transfer of knowledge and sharing of resources between HH. Social network linkages were not a part of this version of FLORES in order to simplify the model, but may be a useful tool to include in future versions.

11. The **travel time** between the household location and each land holding was not incorporated into the model. An Euclidean distance measure could be calculated in AME, but was not due to time constraints. However, a cost surface would provide a more realistic means by which travel times could be calculated and such functionality would be more difficult to implement in AME and is best performed using a AME-GIS linkage.

12. There was no information on the **spatial distribution of land holdings** or the variety of land holdings by agricultural system (e.g. how many paddies, rubber plots, each household had and where). This would impact both travel time between HH and plot and plot and market, and these elements were left out of the model.

13. The study site chosen for FLORES was assumed to be a closed system and that no villages/HH outside the study site were affecting landcover in the study area. This is unrealistic, but fortunately physiographic boundaries likely limit these effects. Other areas lacking such physiographic barriers at the study area boundaries should consider these external factors.

14. Others : Temporary HH locations

    Boundary issues

    Plot adjacency, etc.

Report on the working group Household decision making.

Tuesday,

We introduced ourselves, and spent part of the afternoon talking about the ethnography of this part of Sumatra and part talking about economic models of decision-making. Carol had written some decision-making "stories" just to give the others an idea of some of the factors affecting decisions. By the end of the day we had identified the skills of the various folks. Francois, Mandy and Tom were the modellers. Carol and Laxman had local knowledge. Chimere's interest focused on tenure issues, illuminating aspects of the local situation by his Africa-based questions. Martine and David brought in the economic perspective. This was an early, building block and labour allocation phase.

Wednesday

We divided into an internal group and an external group. Mandy and David made connections with the other teams, and Mandy began to conceptualise the parts of our model and how it might link to others. The larger internal group continued using Carol and Laxman as "expert informants" about local conditions, while figuring out how the model might be pieced together.The knowledge expertise came through the concept of objects variables and influences. By the end of the day, Francois and Mandy had developed a preliminary model (squares of topics, with the idea of having a land management decision-making component, an economic component, and a population component (initiated by Hartmut, and then worked on further by Tom). Carol developed an estimated data set of time allocation by month to the topics we identified as important. It was a conceptualisation phase.

Thursday

The conceptual model of decision making was presented to Jasper to check its feasibility. We continued working on the preliminary models, filling in ethnographic detail, with the modellers getting additional training in AME. We tried to begin thinking about the policy levers and the indicators, but it was hard to do, since we felt we had so much internal work to do. We had sporadic discussions with other teams about how to link NTFP harvesting and production, how to give the crops people the labour information they needed, what kinds of forest we would be using and what we'd get out of it. And we continued plugging away at the model. By the end of the day, Tom had a prototype population model on the computer; Mandy, David and Martine had made good progress on defining the stocks and the links among non-spatial aspects of household decision-making; and Carol, Laxman, and Chimere were working with Francois on the plot-related labour allocation. Gedde was brought in to provide more specific information on prices. By the end of the day, Francois and Martine implemented a first AME version of the economic components. This was a consolidation phase.

Friday

The algorithm of decision-making model was provided by Jasper. We were supposed to have a prototype model completed by Friday night. We all continued working in our sub-groups on the three model components, gradually coming to understand the probable links with other groups and negotiating the exact kind of information we all needed (should pigs come from single plots or from the forest pool? should each plot be identified with a particular family or not? do we need the age of forest plots or would the diameter of the trees do?). Carol and Laxman were interrogated about ethnographic details. Few hours later, Tom and Laxman had made good progress on the population model; Mandy, David and Martine were doing well with the economic aspects. Carol and Francois were struggling with the labour allocation model. By the end of the day, a discussion with Robert led to an agreement: we agreed that if our model failed, our fall back position would be to use the pFlores model for decision-making.

Saturday

We were under real pressure to complete our models. The population model was up and running first. By early evening the economic model was running too, though both still had bugs (and many unfinished items). By 9 PM, the model for allocating labour to various plots was still being made. Francois and Carol finalised a list of activities, re-estimated the times for men, women, children and old people to devote to those activities, under various conditions, on various plots and at various times of the year. At midnight tested population and economic models have been provided. For the land use decision module, the model of perception and the model of action have been provided. Robert did the program to compute the data.

Monday

Plugging the sub-models together.

Workshop on

Common Pool Resources and Multi-Agent Simulation (CORMAS)

CIFOR, 5-6 and 8 February 1999
Animated by François Bousquet (CIRAD)

List of participants

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